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RESEARCH OVERVIEW AND ANALYSIS.(U)
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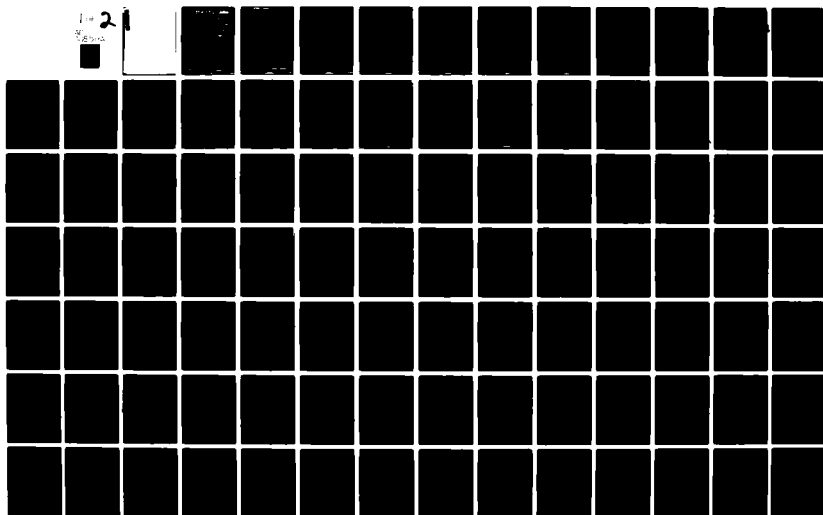
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21. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Research Overview and Analysis report by the USMB's Research Staff provides a comprehensive review and analysis of metric research. As part of this effort, the project reviewed all Board research studies, the General Accounting Office's study, the National Bureau of Standards' U.S. Metric Study, as well as other metric studies and surveys.		

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The "Research Overview and Analysis" report examined the metric research literature from three different but complementary perspectives. The perspectives are: (1) Board Representation and Constituencies; (2) Mandates of the Metric Conversion Act; and (3) National Accounts (a structure grossly representing the operations of the U.S. economy). Besides providing supporting information for the Agency's summary report, the overview examined in detail the findings and conclusions of all the Agency's research effort to identify important matters that remain to be examined.

The report shows that research has made an exhaustive coverage of most of the Board's constituencies and the 11 mandates of Section 6 of the Metric Conversion Act of 1975 (P.L. 94-168). The National accounts have been covered in a descriptive and more qualitative fashion.

A major finding of the report was the lack of practical methods as well as easily assessable, reliable and homogeneous data that would allow for quantitative analysis of the effects of metrication on the national economy. However, single purpose studies on a sector basis would provide for an aggregation of results and projection of metric status in the U.S.

The report found that there were still unanswered issues concerning the impact of metrication on the economy and society, (e.g., the interactions of metrication on export trade, the effects voluntary metrication pose for near term business planning and investment decisions, and the effects and implications of voluntary metrication on the U.S. economy).

RESEARCH OVERVIEW AND ANALYSIS

**OFFICE OF RESEARCH
OF
THE UNITED STATES METRIC BOARD**

**Prepared
by
United States Metric Board
1600 Wilson Boulevard
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Arlington, Virginia 22209**

April 1982

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RESEARCH OVERVIEW AND ANALYSIS

I. INTRODUCTION

A. Overview

This paper is a detailed review of the research activities of the United States Metric Board, carried out since the inception of the Board. The review consists of examining the research from three different perspectives:

- Board representation and other constituencies.
- Mandates of the Metric Conversion Act of 1975 (Section 6(1) through (11)).
- National income and product accounts (the national economy).

This paper serves two purposes:

- It compiles a comprehensive summary and the significance of the research findings and helps identify important matters remaining to be examined.
- It provides the basis for the research portion of the Board's final summary report to the President and the Congress.

The Research Committee allocated the USMB research priorities in an effort to be as complete as possible in addressing the potential areas of concern--both those specified in the Metric Conversion Act (particularly, Section 6(9)), and those of emerging interest. The only constraints beyond budget considerations were that larger studies would have to be started early and divided into reasonable, one-year components, so as to allow other research studies to be conducted during the same time and thus provide a balanced range of topics explored in any one year. Main examples of this policy are the worker and small business sequences of studies. The initial and principal guidance for the research program comes from the Act, wherein the Congress suggested a series of topics of importance (i.e., workers, different occupations, industries, consumers, small business, the economy, international trade, federal procurement, transition periods, national defense, and legal impediments). Certain activities conducted outside the Office of Research, but research-like, are incorporated into the discussion (e.g., the legal studies directed by the Office of the General Counsel, the consumer program

assessment conducted by the Office of Public Awareness and Education, and surveys of engineering standards writing organizations by the Office of Coordination and Planning).

Table 1 identifies the Board's research activities and the status of each at this writing, divided by major topics.

As can be seen from the table, the research activities have covered, or at least touched on, most of the original agenda.

The economic/econometric sequence of studies was initiated in FY-82, with an econometric models and data resources study. Because of limited resources, the area of international trade was not explored but the topic was included in the FY-83 planned program. Preliminary talks in late Fiscal Year 1981 were held with the U.S. Department of Commerce officials concerning a possible interagency agreement for joint research. However, due to budgetary constraints, this activity was dropped for FY-82.

Assessment of the total research effort is best considered in light of the Act, both directly as in Section 6(9) ("... conduct research, including appropriate surveys ...") and indirectly, as in Sections 6(1), 6(2), 6(7), 6(8), 6(10), and 6(11), where research efforts are complementary to other efforts in the Agency. The assessment of this paper derives from the three perspectives: (1) the Board representation and other constituencies; (2) the mandates, as written in the Metric Conversion Act; and (3) the economic sectors of the country as a whole, as categorized in the National Income and Product Accounts. The reason for the latter is that it provides a potential for an exhaustive and non-overlapping representation of the nation's economic interests from both the supply and demand sides. This is one way of assessing the extent of gaps in the coverage of the research efforts.

The reasons three perspectives are pursued are:

- o the perspectives are each independently of considerable interest and value, and
- o the three complement each other.

TABLE 1

USMB RESEARCH ACTIVITIES

<u>TOPIC</u>	<u>RESEARCH PROJECT</u>	<u>APPROXIMATE COST</u>	<u>STATUS</u>
<u>Legal Issue</u>	A Study of Metric Measurement and Legislation (2 Vols.), Middlesex Research Center, Inc., September 1979.	\$75,000	Completed (79)
	Providing a Metric Option: Can Laws and Regulations be Amended in a Timely Manner?, U.S. Metric Board, December 1979.	(OGC) ¹	Completed (79)
	Antitrust: A Handbook for Metric Planning and Conversion, U.S. Metric Board, May 1980.	\$10,000	Completed (80)
	The Impact of Laws on Metric Conversion: A Survey of Selected Large U.S. Corporations, Newman & Hermanson Company, February 1982.	\$10,000	Completed (82)
<u>Workers</u>	Effects of Metric Conversion on Measurement, Specification and Process Sensitive Occupations, U.S. Metric Board.	\$70,000	Draft Report
	Analysis of the Survey of Selected Occupations Sensitive to Measurement Change, U.S. Metric Board.	(Res. Div.) ²	Draft Report
	Effects of Metric Change on Workers' Tools and Training, Middlesex Research Center, Inc., July 1981.	\$75,000	Completed (81)
	Effects of Metrication on Safety in the Work Place for Selected Occupations, Middlesex Research Center, Inc., April 1982.	\$75,000	Completed (82)

Small
Business

Survey of Small Business:
Issues in Metric Planning
and Conversion, DAMANS
and Associates, Inc.,
December 1980. \$70,000 Completed (80)

The Search for Small Business
with Investments in Metric
Production, J.F. Coates, Inc.,
June 1981. --- 3 Completed (81)

The Consequences of Metric
Production for Small Manufac-
turers (2 Vols), J.F. Coates,
Inc., February 1982. \$90,000³ Completed (82)

Going Metric: Is it for You -
Planning Models for Small
Business Manufacturers, Wholesale
and Retail Firms, and Service
Firms, Birch & Davis Associates,
Inc. \$85,000 In Process

Small Business Productivity &
Metrication, Small Business
Administration. \$10,000 In Process

Status
Assess-
ment

U.S. Metric Board Survey of
Selected Large U.S. Firms and
Industries, King Research, Inc.,
May 1980. \$10,000 Completed (80)

Conversion Data Project, U.S.
Department of Commerce, January
1980. \$10,000 Completed (80)

Research Techniques for Assess-
ing Status of Metric Use,
J.F. Coates, Inc., February 1981. \$10,000 Completed (81)

Metric Usage Study: A Look at
Six Case Histories, U.S. Metric
Board, 1980. (PAE)⁴ Completed (80)

Consumers and the United States
Metric Board, U.S. Metric Board,
August 1981. (PAE)⁴ Completed (81)

Survey of Consumer Attitudes and Awareness of the Metric Conversion of Distilled Spirits Containers, Applied Concepts Corporation, December 1981.	---	5	Completed (81)
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Supermarket Survey, U.S. Department of Agriculture.	\$50,000		In Process
-----------------------------------------------------	----------	--	------------

Metric Use in the Machine Tool Industry -- A Status Report and Test of Assessment Methodology, J.P. Coates, Inc., April 1982.	\$10,000		Completed (82)
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Standards
Organizations

Status of Metric Conversion - A Brief Survey of U.S. Standards Writing Organizations, U.S. Metric Board, in press (1982).	(C&P Div) ⁶		Draft Report
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Status and Outlook for Metric Conversion of Standards: The Views of Nine Selected Major Standards Development Bodies, U.S. Metric Board, in press (1982).	(C&P Div) ⁶		Draft Report
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Policy
and
Issues

A Study of Metric Conversion of Distilled Spirits Containers: A Policy and Planning Evaluation, Final Report on Findings and Lessons Learned, Applied Concepts Corporation, October 1981.	\$75,000 ⁵		Completed (81)
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A Study of Metric Conversion of Distilled Spirits Containers: A Policy and Planning Evaluation, Comprehensive Report on the Conversion Process, Applied Concepts Corporation, August 1981.	---	5	Completed (81)
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The Conversion of Retail Fuel Pump Computers to Sale by the Liter, U.S. Metric Board, June 1979.	(RCP) ⁷		Completed (79)
--------------------------------------------------------------------------------------------------	--------------------	--	----------------

A Survey and Assessment of
Econometric Models and Data
Bases for Their Applicability
as Research Tools for the
United States Metric Board,
Applied Concepts Corporation,
December 1981.

\$10,000

Completed (82)

Federal Procurement Metrication:
Appropriateness and Methods,
Science Management Corporation.

\$65,000

In Process

-
- 1--Office of General Counsel
 - 2--Research Division
 - 3--Two Reports Developed under Contract AA-80-SAC-X8604
 - 4--Office of Public Awareness and Education
 - 5--Three Reports Developed under Contract AA-80-SAC-X8602
 - 6--Coordination and Planning Division
 - 7--Office of Research, Coordination and Planning

B. Perspective No. 1: Board Representation and Other Constituencies

The specific designation of USMB Members as representatives of selected constituencies has been combined with other constituencies identified as important subsequent to the enactment of the legislation. The list is shown in Table 2, with the constituencies presented in the order of their citation in the Act.

Applying slightly different criteria than used to identify research and research-related activities for Table 1, 22 distinct activities have been defined for Perspective No. 1. In addition to USMB sponsored work, the analysis includes the basic GAO study (Getting a Better Understanding of the Metric System ...), the NBS study (A Metric America ...) and a GAO analysis of shipping containers. Some of the 28 USMB reports (Table 1) have been combined to yield the 22 activities cited in Table 2. Appendix A contains the results of the application of this first perspective.

C. Perspective No. 2: Functional Mandates of the Metric Conversion Act of 1975

The research activities have been related to the mandate parts of Section 6 of the Act. Two considerations are used to relate the research findings of the Act's mandates:

- (1) the extent to which the planned results of the research are related to the mandates, and
- (2) the extent to which serendipitous results of the research are related to the mandates.

Examples may help to clarify the application of this perspective. With reference to the first consideration, Section 6(9) of the Act identifies particular social and economic categories as possible subjects for research. Thus, by conducting studies of those categories, the research activities respond directly to that mandate.

With regard to the second consideration, Section 6(7) refers to information and education programs. While no research activity was directed toward information and education per se, research findings reinforced the observation that many people have had misconceptions about national metric policy. Research surveys carried out under Board's auspices have served to convey information about national metric policy and the role of the U.S.

TABLE 2

PERSPECTIVE NO. 1:
CONSTITUENCIES* AND RESEARCH STUDY COVERAGE

<u>Constituency</u>	<u>Number of Studies (Out of 22) Dealing with Constituency</u>
Engineering	9
Science and Technology	9
National Association of Manufacturers	15
U.S. Chamber of Commerce, Retailing and other Commercial Endeavors	8
Labor	10
State and local government	7
Small Business	19
Construction	14
Weights and Measures, and Standards	9
Education	7
Consumers	9
Federal**	7
International**	9

* In the order of citation of the Metric Conversion Act of 1975.

** Not represented specifically on the Board.

Metric Board. This dissemination of information has the effect of an information program, thus serving some of the needs of Section 6(7). Appendix B contains the results of the application of the second perspective.

D. Perspective No. 3: National Income and Product Accounts

In the structure of the National Accounts, the national product is broken out two ways: the consumers of goods and services (the household sector) and the producers of goods and services (the business sector). From the National Accounts perspective most of the research is represented by surveys that elicited qualitative information rather than quantitative data. However, the qualitative analysis allows for strong inferences to be drawn with respect to the specific studies. In most cases, however, statements of a macroeconomic nature cannot be made as to the total U.S. economy.

The household sector is represented by the final consumption of goods and services. This consumption side (usually known as final demand) consists of personal consumption, government purchases, investment, and net exports.

The business sector as producers supply goods and services to the household sector as well as to intermediates. The accounts for this production side (also known as supply side) are corporate and non-corporate entities. These entities are also categorized by industrial sector as given, for example, on an input/output table.

Most of the USMB research activities are relevant to the supply side of the economy, both on the factor input side as well as on the product output side. The worker tool study is an example of the former dealing as it did with the business community requirements for labor, tools, and training services. Tools and training services are examples of "intermediate" demand, the requirement of one industrial sector for the output of another.

The Fortune 1000 and small business surveys relate to the product side of the business sector, since they deal with the prices and provision of the goods and services. Likewise, the studies in the area of laws and regulations relate primarily to the product side, dealing with marketing and packaging. Building codes and antitrust regulations are on the input side of the business sector. Several industrial groupings are mentioned specifically in the studies.

The demand side of the economy is represented in the research work of the Board more from a qualitative view than a quantitative aspect. In the household sector (consumption expenditures), there are the distilled spirit containers study with its consumer surveys, the USMB Consumer Program Report, and the USDA Supermarket Survey. In the government sector, the Federal Procurement Study directly examines the metric implications of the Federal government's demand for goods and services. The demand side accounts of investment and net exports are generally addressed qualitatively. Investments, incorporating as it does capital equipment such as machine tools, is potentially a beneficial area for research, since it deals with both the household demand for securities and the business demand for plant and equipment. A limited quantitative study of the machine tool industry has recently been completed.

On the supply side, many industrial groupings have not been studied from a quantitative macroeconomic level as to metric impact. This area is a chief candidate for exploration in the econometric program.

Appendix C contains the results of the application of this last perspective. Because of its broad nature and the fact that the research program was designed to criteria other than those reflective of the national economy, the results of the third perspective are more general and indicative than are those of the first two perspectives. Thus, a primary product of the use of the third perspective is direction for the future--the definition of unmet needs and questions that remain to be answered (see Section III).

E. Overall Assessment and Additional Analysis

The research effort has covered a very wide field of actual and potential impact of metrification activity, emphasizing workers, small business, and the status of metrification in the U.S. Computer software, international impacts, and agriculture have not yet been examined because of limited resources, although research suggestions have been made by interested parties as part of the research calls conducted by the Board and planned programs have incorporated such subjects. Gaps have not been due to inadvertance, but to limited resources. Both the GAO and the NBS reports play a role in the analysis of findings, to identify comparable and consistent, as well as inconsistent, findings and to help define what information gaps still exist.

The three perspectives are seen as complementary and, together, offer a structure for developing a more complete picture of metrification than each does alone.

II. SUMMARY

The major findings of the Board's research and research-related activities, as well as those from allied research, are presented here, using the mandates (Section 6(1) through (11)) of the Metric Conversion Act of 1975 as a convenient structure. The mandate format is one of the three perspectives or viewpoints used to examine all the research activities and develop general findings. It is used in this summary section because it is convenient and provides a recognizable frame for the majority of readers of this report. The contributory findings derived from the other two perspectives (the constituencies and the national accounts of the economy) are integrated into the mandate structure. General conclusions, developed from accumulated findings are identified and presented.

Each mandate is paraphrased here; the complete mandates are presented in Appendix B, with the detailed findings. The detailed findings derived from the other two perspectives (constituencies and economy) are found in Appendixes A and C, respectively.

A. Mandate 1: Consultation

Consultation and consideration of the interests, views and conversion costs of commerce and industry, science, engineering, labor, education, consumers, government agencies, standards developing organizations, metric conversion planning and coordinating groups, and others.

1. Findings

Little is seen in the way of sector planning and coordination, particularly on the part of small businesses and on the part of large firms making unilateral conversion decisions in their own interests. The prevailing disposition among large businesses is a "wait and see" attitude; coordination on metric matters between suppliers and customers appears limited.

There are no major legal barriers to conversion, but the antitrust issues and building codes are considered carefully by firms contemplating conversion. The antitrust matter concerns some firms ostensibly interested in cooperative planning, in spite of available published guidelines containing information on how to carry out cooperative planning without restraint of trade actions. Other classes of laws also of some concern are fair packaging and labeling, and weights and measures.

Small firms tend to make metric decisions as they make most business decisions, in response to customer demand and then in accordance with their own perceptions of the most personally beneficial approach, without resorting to detailed planning and analysis. Firms with no conversion experience expect conversion costs to be high and the problems to be many and major; experience shows these fears to be unwarranted.

Specific classes of occupations (e.g., medical, health, mathematical, physical science, mechanics, and machinists), comprising about half of the occupations defined by the U.S. Department of Labor, are most susceptible to changes in the system of measurement units. Some groups will require training and reorientation. In addition, others will require new tools. In most cases training is provided by and paid for by the employers; often, new tools are the responsibility of the workers. Experience to date suggests that workers do not or cannot avail themselves of tax deductions for new tools, when they have that right.

Because the decisions have been principally individual firm or industry decisions, consumer involvement in metrification decisions has been minimal to date. On the one major consumer product conversion examined (that of distilled spirit containers), consumers were generally unaware of the contents of the containers normally purchased, but such ignorance for this conversion did not appear to concern the consumers.

2. Conclusions

The driving force for conversion in the U.S. is the large, individual, multi-national manufacturing firm; the decision is generally made by the individual firm in its own interest, not in consultation with others.

For small businesses, metrification is neither voluntary nor forced; neither are there particular benefits from (other than keeping specific customers), or substantial costs of, metrification.

B. Mandate 2: Procedural Guidelines

Appropriate procedures to allow groups to formulate and suggest specific conversion coordination programs.

1. Findings

Formal procedures and policies provide a mechanism for the participation and encouragement of groups in coordinative activities of conversion. However, there is little evidence that the groups at risk (e.g., consumers, labor, and small business) are aware of or interested in the procedures and policies, or have been or are being involved in conversion planning.

2. Conclusions

As previously noted, the driving force for conversion is the large, individual, multi-national manufacturing firms, which generally make unilateral conversion decisions in their own interests. The others involved (particularly small business, but also consumers and workers) are required to follow along, not in a truly forced manner but not in a truly voluntary manner either.

C. Mandate 3: Public Hearings

Publicize proposed programs and provide opportunity for comment.

No direct research-related activity is associated with this mandate. The analysis of the gasoline retail dispenser computer conversion did result in the wide sharing of conversion cost data among all groups affected: distributors, retailers and consumers. Similarly, the American National Metric Council's Chemical and Allied Products and Instruments Sectors' Conversion plans were publicized by the Board during its analyses and review of the plans.

D. Mandates 4, 5, and 6: Standards Conversion, Retention and Consultation

Encourage the conversion of engineering standards (mandate 4) and the retention of U.S. engineering designs, practice and conventions (mandate 5), and consult and cooperate with domestic and foreign organizations and agencies concerned with increased use of metric units and standards (mandate 6).

1. Findings

The lack of metric standards from traditional U.S. standards development organizations is at least an

inconvenience, if not a costly matter to some firms providing metric sized products. Because market demand for metric dimensioned products is currently limited, there has been little movement in industry or government for metric standards development to support planned product conversions to metric. Most standards development organizations have not viewed foreign origin standards as displacing U.S. non-metric standards and the use of inch-pound units has not been a significant deterrent to international acceptance of U.S. inch-pound products. The major problems for developing and using metric standards has been the lack of demand for them which is in turn due to the lack of metric basic materials and components. Other problems are potential safety issues as well as consumer resistance in the form of lack of demand for metric dimensioned products. It is felt that the costs of developing new metric standards are about the same as inch-pound versions. Should demand for metric standards increase significantly, the standards developing organizations have an infrastructure in place to respond to the increases.

The apparent dichotomy between the firm or industry stating a desire for more metric standards and the standards writing organizations perception that there is nominal demand for metric standards may be due to characteristics of the voluntary standards process where perceived demands for a new or converted standard must raise above a certain threshold in order to be recognized and initiated. It is probable that a particular industry alone may not constitute sufficient demand where the development of a new or converted standard may be expensive or time consuming.

2. Conclusions

Metric standards development is neither a major issue nor problem for the standards developing organizations. The driving force for metric standards is sufficient customer demand. Conversion by U.S. industry to metric is proceeding relatively slowly. While some inconvenience may result from lack of convenient and timely availability of new "hard metric" U.S. standards, other economic and social factors are far more significant considerations in the decision to convert or not convert manufacturing processes or products to metric.

Metrication may be used as a justification for rationalization and simplification. Some completed metric conversions (e.g., wine and distilled spirits containers) were, in truth, partially the result of an industry desire for rationalization.

E. Mandate 7: Public Information and Education

Assist the public, through information and education programs, to become familiar with the meaning and applicability of metric terms.

1. Findings

While considerable effort on the part of the Board has been devoted to this mandate, no specific research or research-related activities have been carried out relative to it. All surveys and reviews (studies of small business, large business, consumers, workers, legal and policy issues) have identified the same phenomenon: the national policy on metrication, the significance and meaning of the Metric Conversion Act of 1975, and the role and responsibility of the United States Metric Board are, to varying degrees and with variable importance, either misunderstood or not well understood.

Studies of workers have identified a widespread need for tailored training for conversion, with emphasis on a need-to-know level of proficiency. There is duplication of training models and information for similar types of workers, implying added and unnecessary costs. There is some evidence that a clearinghouse of metric training information (models, materials, and procedures) would be of use to the private sector.

2. Conclusion

Widespread dissemination (receipt and application) of the Board's research and research-related findings, in particular to trade and business associations and labor unions, would have a beneficial influence on the level of understanding of the implications of the metric system and conversion.

F. Mandate 8: Status Assessment

Collect, analyze and publish information about the extent of usage of metric measurements, evaluate the costs and benefits of metric usage, and make efforts to minimize adverse effects of metric usage.

1. Findings

The first and second clauses (collect, analyze and publish information about the extent of use of metric measurements, and evaluate costs and benefits of metrication) are responded to by the research program. There is widespread, but shallow metric capability and activity throughout the American industrial community. Large, multi-national firms take the leadership in conversion and in some cases (e.g., automobile and farm machinery manufacturing) move towards essentially full conversion. Costs, to the extent reliable data and information are obtained, are low, both in absolute terms and in comparison with the other costs of doing business. Metrication is carried out by the private sector in a logical, least-cost manner. There is a striking difference of views of costs and benefits between those who have experienced conversion and those who have not. Those who have not, believe the costs will be large and unwarranted while those firms who have converted generally have found the costs to be negligible.

At present, assessment of metric status at the national economy level and specific industry levels cannot be handled through econometric modeling or through aggregation of data because little metric data exists. One of the reasons this data is limited is because it is considered proprietary by some firms. In addition, there are problems with the data which is available, one being a lack of homogeneity since these data were captured using various metric status definitions.

While no specific research or research-related activities have been devoted to the third clause of this mandate (minimizing adverse effects), all research findings and results have been considered and integrated into the planning and coordination efforts of the Board. These efforts are detailed elsewhere. (See the U.S. Metric Board's Annual Reports for 1979 and 1980, and the Board's summary report to the Congress and the President).

2. Conclusions

Metric status information is needed by companies so that more informed decisions can be made concerning industry, suppliers, customers and the implications of that status for a company's or industry's competitiveness in domestic and world markets. At

present corporate decisions about metrication are made in the face of considerable uncertainty and lack of information.

The collection, collation and analysis of status information for providing a national assessment of metrication activities is not a simple or inexpensive task. The information is not readily available from easily accessed sources in forms directly applicable. There are many different audiences with vastly different needs for status information.

However, surveys using in-depth discussions with industry entrepreneurs, managers and workers, supplemented by qualitative analysis of the behavior of representative companies is an appropriate and relatively low cost approach to status assessment. Such studies on a sector by sector basis produce information of practical value to the industry and public sector decision makers.

While the costs and benefits of metrication have been assessed (the former to a greater extent than the latter), the larger question of the costs, to the nation, of the present approach to metrication have not been addressed. A beginning is discussed in Section III.

G. Mandate 9: Research

Conduct research, publish the results, and recommend to the Congress and the President necessary action to deal with unresolved problems.

This is the primary mandate justifying and guiding the research effort of the Board. All research activity has been conducted in accordance with this mandate. Research findings of sufficient importance were singled out and presented to the Congress and the President, as required by the Act. A particular case had to do with workers in converted industries who regularly buy their own tools. Many such workers cannot or do not take advantage of the tax deductions available to them for tool purchases. The full cost of adding metric tools to their necessary array of tools was borne, and is being borne, by the workers. The Board judged the problem to be of the nature contemplated by the Act and thus called attention to the research findings. Other findings have been identified through the annual reports to the Congress and the President, and through the distribution of

specific research reports and summaries to the Congress, the President, and key persons in the Executive Branch and the private sector. The findings of the research program are presented in various ways throughout this summary. To respond more directly to the discussion of the ninth mandate, the research areas suggested by the Congress are presented with brief observations about each, resulting from the research activities.

1. Findings

a. Impact on workers and different occupations

While a considerable portion of U.S. occupations can be affected by a change of measurement systems, an equally large portion of the occupations are not sensitive to measurement change.

Some workers required to purchase new tools as a result of their employers' metrification absorb the entire costs of the new tools.

b. Impact on different industries

For both large and small businesses, particularly manufacturing firms, the costs of conversion are inconsequential and the decision to convert is made like any other business decision.

Factors other than metrification, such as the general state of the economy and interest rates, are far more important to the business firms.

There are no major legal barriers to conversion. Legal areas of greatest concern to firms contemplating conversion are antitrust matters and building codes.

c. Possible increased costs to consumers

Consumers have played no significant role in large scale conversions initiated to date.

There is a potential for metrification to be used as device to justify price increases to consumers, not related to conversion, even when increases are justifiable on other grounds.

d. Impact on society and the economy

Efforts to examine the relationships between metrification and the economy were initiated only late in

Board's existence. Only very general observations are available. Most of the linkages between the research studies and the aggregates of the national accounts are interesting but not in a systematic, comprehensive way. The reason is plain: the research program was not designed, at the outset, to address the issues of the national economy.

There is a need for further study, examining metrication in the context of the national economy particularly by industry areas or sectors. Such studies would be a cornerstone for any attempt to draw nationally valid conclusions about the effects change to metric measurements has on the U.S. economy. (The studies could also form the basis of an examination of the effects of the economy on the progress of metrication.)

e. Effects on small business

The direct costs of conversion, particularly of manufacturing firms, is insubstantial and in many cases not even identifiable.

Conversion of small businesses is neither voluntary nor forced, not a search for new business markets or other benefits, not dictated by any one company, but rather a result of general industry trends.

f. Impact on the international trade position of the United States

With the exception of large, multi-national firms, there is little evidence of conversion to take advantage of international markets. There has been a decline in the U.S. machine tools industry's share of the international market. This market is four times the size of the domestic market. However, this decline has been masked by the inflationary impact on the dollar value of machine tool sales. The issue of the real potential and need to convert to compete internationally has not yet been fully assessed by the Board's research program.

g. Appropriateness of and methods for using procurement by the Federal Government as a means to effect conversion to the metric system

At this writing, the initial study of this topic is underway. Information is to be provided in July 1982.

h. Proper conversion or transition periods

A variety of conversion periods have been cited as optimal by different classes of firms; eight to ten years seems to be the norm for a nationally coordinated program. No assessment has yet been undertaken to determine the costs, to the nation, of alternative transition periods.

i. Consequences for national defense

With the exception of the Federal procurement analysis now underway, no specific Board research activity has focused on national defense matters.

In addition to the work cited above, additional topics have been examined: legal constraints on metrication, discussed in connection with mandate 11; status measurement and the development of research methods to respond to mandates 8 and 9; and status assessments of standards and standards writing organizations to respond to mandates 4, 5, 6, 8 and 9.

2. Conclusions

The research program was conceived to directly address the issues cited by the Congress, because those issues are widely accepted as important. The overall conclusion that can be drawn from the collection of findings and observations is that, under the present condition of private sector initiation of metrication, conversion is taking place within the existing mores of the market place. No widespread trauma or dislocation is occurring. Those groups felt, by the Congress and others, to be "at risk" under conversion (small business, workers, and consumers), are not being particularly harmed or particularly benefited by the changes undergone and on-going. A small number have borne unexpected burdens (e.g., workers required to buy new tools and consumers being annoyed by gasoline, wine, and distilled spirits conversions), but these have been minor in a national, holistic sense.

The direct costs of conversion, under the present process, is small and trivial, particularly in comparison with other economic problems faced by society. The direct benefits of conversion, except to the large industrial firms generally initiating metrication, are also small and inconsequential (except to the degree that conversion means keeping an important customer or a job).

What is lacking is an understanding of the broader range of cost and benefits: the national costs of maintaining multiple measurement systems; the lost opportunity costs; the disutility (or utility) of gradual, private sector initiated conversion, extending through many years, as compared with a nationally planned and coordinated conversion process; the balance of payment benefits or costs resulting from conversion; in short, a national costs and benefits picture.

H. Mandate 10: Annual Report

Submit an annual report to the Congress and the President.

All research and research-related activities have contributed to the annual reports published to date. No specific observations need to be made to those contributions; findings discussed in the annual reports are reviewed throughout this summary.

I. Mandate 11: Federal Structural Mechanism for Laws and Regulations

Submit a report on the need for an effective structural mechanism for converting customary units to metric units in statutes, regulations and laws at all levels of government.

1. Findings

The specific actions in response to the last mandate were a comprehensive review and analysis of laws, regulations and ordinances affecting measurement and the development of the Board's position on the need for a structural mechanism for changing the laws. The principal observation is that there was no need for Congress to provide a new structural mechanism. The observation was based on findings that:

Existing laws and regulations at all levels of government do not constitute significant legal barriers to voluntary conversion efforts.

Not all legal references to customary units require change.

Most of the required legal changes can be accommodated through administrative rule-making rather than legislative action.

Voluntary conversion activity underway at the time of the study was not of sufficient magnitude to strain the effectiveness of existing mechanisms. The Board could not state whether voluntary conversion activity was being unduly inhibited by perceived legal barriers and perceived limitations of available change mechanisms.

Early Board research provides data suggesting that perceptions of legal barriers may inhibit conversion. Further study indicates that some perceptions of inhibiting laws and regulations exist, but that there is strong recognition of the suitability of available change mechanisms. Use of the USMB-endorsed Uniform Metric System Procedure Act could alleviate legal inhibition of metrication. Additional work in the general area of laws and regulations is represented by the Board's antitrust guidelines; see the discussion related to the 4th, 5th, and 6th mandates (Section D, above,) for the observations.

2. Conclusions

While perception of legal inhibitors of conversion exist, they are not widespread nor are they serious inhibitors. Large firms contemplating conversion are sometimes particularly concerned about antitrust laws inhibiting coordination of plans among firms. Such fears are unwarranted, given the proper use of existing guidelines and rulings. State and local building codes can impede metrication in the construction and allied industries, but suitable corrective mechanisms exist.

III. KEY GAPS AND RECOMMENDATIONS

The foregoing provides a systematic review of the contributions of the Board's research program. The following comments are directed to the remaining research task--the unmet needs.

When the Office of Research was formed at the USMB, one of the areas of inquiry was to be a systematic and country-wide estimate of the effects of metrication on the U.S. economy, under both voluntary and mandated regimes.

A combination of factors delayed the program. First, there was the recognition that such a study could absorb the entire research budget for a considerable period of time, without a guarantee of success. Second, there was a need for a number of smaller, but critical projects, that could

be carried out for considerably less cost than one large econometric study. It was felt the smaller studies would provide valuable new knowledge to the Board for various policy deliberations.

It has become clear from recent econometric models' reviews that much data gathering would precede the use of available econometric models. The cost of gathering homogeneous and in some cases proprietary metric data for all sectors of the economy may make such a macroeconomic analysis prohibitive. The exact costs would also depend upon the model's sophistication, the extent to which outside experts would be required and the degree of previous research (both metric and nonmetric) in the sectors being analyzed. The Board need not necessarily subscribe to the host of forecast services available in the market place. Single purpose studies on a sector by sector basis would probably be a more cost-effective approach to conducting research, at least for an initial period and until more is learned through the sector-specific analyses.

However, in ideal form, the composition of the large scale economic study would be of the following form.

In first order of importance would be a "metric goods and services" input/output table. This would consist of the fraction of each industry's metric output which was shipped to other industries, and to final demand. Input/output tables range in size from less than 10 by 10 to more than 400 by 400 cells. The larger, the better for the metric investigation, because of the danger of missing metric effects in highly aggregate data. The preparation of the table would proceed in two stages: (1) specifying what the metric products are, and (2) what the dollar traffic for them is. The former would require new methods, building on lists of metrology-sensitive products used in international trade. The second phase could reasonably be carried out by the Census Bureau and the Bureau of Economic Analysis, both of the Department of Commerce.

In order to predict prices and bottlenecks, metric capacity estimates for the industries would be required. The standard input/output table doubles as a capacity measure for total output, but would not accurately reflect the abilities of the industries to respond to increased metric demand. Some assumption would be required, such as proportionality; that is, metric capacity might be assumed to take the same fraction as does metric output, for example.

After the input/output table is created, it should be relatively routine to incorporate it into an existing macro-model, such as those already reviewed by the Board. A way would have to be found to portray the effects of the smaller metric input/output table without losing the interactions of the much larger non-metric input/output table. An interactive scheme could be devised to "back into" the estimates desired.

An advantage of this approach is that various groups would be interested in results generated at all stages of the investigation, and might well be tapped for expert advice, particularly in the first phase of the data generation. Further, the composition of the input/out table resulting from the study would give approximations to industry supply and demand models--themselves of interest.

The ability to perform macroeconomic analysis is dependent upon the availability, reliability and homogeneity of the data for input to "drive" the models. At present, there is a scarcity of metric data to drive these models. For all but a few sectors, USMB research would be needed to develop detailed sector models to analyze sector-specific metrication issues. The development of improved indicators and techniques for evaluating metric conversion status of individual industries and sectors would allow for the aggregation of results and provide a clearer national picture of metrication activities. This can be done through relatively simple and low cost techniques on an industry by industry or sector by sector basis.

The questions that could be answered by this overall approach would be such as:

- o Is the nation losing substantial export trade by operating under a mixed system of measurement?
- o Does continuing the present voluntary system pose serious problems for the future by contributing to business uncertainty in making planning and investment decisions?
- o Will the voluntary system eventually favor those who keep customary measurements and penalize those who convert to metrics?
- o What are the costs and inconveniences of maintaining dual inventories--products measured in metric and in customary units?
- o Would a certain number of years to total metrication cause extreme price (availability) pressures in some sectors?

- o Is there a "best" number of years for mandated metrication or, if not for the nation, for specific industrial sectors?
- o Does setting a target date for metrication cause dislocations in the marketplace, such as price increases or product scarcities?
- o Will metrication growth under the voluntary program stop, remain the same or increase?
- o Do money supply and interest rates affect metrication?

Many industry leaders have expressed concern about what they perceive to be the increasingly uncertain direction of metric conversion in this country. For this reason, industry may hesitate to make major capital investment decisions that involve metrics in the absence of a clear signal of intention from the Federal government. Before putting money on the line, business leaders want and deserve a clear-cut position so they can order mills, systems and machine tools. A broad-based study of the economy and metrication could provide the Federal government with solid answers to use in future decisionmaking about the course of metrics in the United States.

APPENDIX A

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APPENDIX A

PERSPECTIVE NO. 1: BOARD REPRESENTATION AND OTHER CONSTITUENCIES

A-1: Approach

Each of the eleven areas of Board representation listed in Section 5 of the Act are considered in turn in this Appendix. In addition, two other constituencies are discussed in Section A-13 and A-14: (1) Federal Related Constituencies and (2) International and Related Constituencies.

All of the research, research-related, and allied source material studied has been reviewed for this total of 13 constituencies to determine:

- (1) the extent to which the planned and focused results of the research relate to each of these constituencies of the Board; and
- (2) the extent to which ancillary and fortuitous results of the research studied relate to these constituencies.

The studies used for this analysis are listed in the reference table at the end of this Appendix.

A-2: Engineers and Organizations Representative of Engineering Interests

In the materials studied, the interests of engineers appear to be addressed most directly under the heading "Engineering Standards" in Chapter 6 of the GAO report (Ref. 1) and in "Engineering Standards" of NBS's U.S. Metric Study Interim Report (Ref. 2). The conclusions, recommendations, and other items of interest noted in the four U.S. Metric Board Office of Research reports related to all workers (Refs. 3, 4, 5, and 6) also are of significant interest to the concerns of engineers. Finally, it should be noted that the concerns of several of the other constituencies noted in P.L. 94-168 also impinge on the interests of engineers, viz., scientists, the National Association of Manufacturers, the U.S. Chamber of Commerce, the American Federation of Labor and Congress of Industrial Organizations, small business, the construction industry, the National Conference of Weights and Measures, educators and the educational community, and consumers. The additional two constituencies that are not cited in P.L. 94-168 (Federal and International) may also have components of interest to engineers.

Information relating to engineers and organizations representative of engineering interest as cited in P.L. 94-168, appears subsumed under the information presented below for three other groups specified in the Metric Conversion Act of 1975, viz., (1) American Federation of Labor and Congress of Industrial Organizations and by other organizations representing labor, (2) the National Conference on Weights and Measures and standards' making organizations, and (3) educators, the educational community, and organizations representative of educational interests.

Consequently, information about the engineering constituency is incorporated in discussions of the three groups noted above.

A-3: Scientists, the Scientific and Technical Community and Organizations Representative of Scientists and Technicians

As was the case for engineers and organizations representative of engineering interests, that specialized and highly trained subset of workers who are scientists, members of the scientific and technical community, and organizations representative of scientists and technicians are indirectly cited in GAO (Ref. 1) and NBS reports (Ref. 2). They are also relevant to the subject of U.S. Metric Board Office of Research reports dealing with workers in metrology-sensitive occupations (Ref. 3). These include the 46 percent of the U.S. workforce which is sensitive to measurement change (i.e., making measurements, using measurement specified items; and manipulating measurement specific information).

Occupations which are measurement sensitive account for 30.5 percent of the workforce; occupations dimension (or specification) sensitive comprise 12.3 percent of the workforce; and occupations process sensitive comprise 19.2 percent of the workforce. These percentages (when added to the 54 percent of the workforce not sensitive to measurement change) total over 100 percent because of the existence of occupations with more than one form of metrology-sensitivity.

Those occupational areas which include members of the scientific and technical community (as well as engineering) that have occupational titles where more than 50 percent of the workers are involved in jobs that are measurement sensitive include: (1) medical and health workers (91 percent sensitive; 4.6 percent of the workforce), (2) mathematics and physical sciences workers (80 percent sensitive; 0.5 percent of the workforce), and (3) architecture, engineering and surveying (95 percent sensitive; 2.8 percent of the workforce).

As was the case for engineers and organizations representative of engineering interests, further information regarding scientists, the scientific and technical community, and organizations representative of scientists and technicians, within the perspective of the Constituency Framework, will be included in discussions of the AFL/CIO, NCWM, and Educators.

A-4: The National Association of Manufacturers

The NAM represents manufacturing companies of every size and type. It is concerned with all major governmental actions involving business and takes the initiative in proposing, supporting, or opposing legislation and regulations which vitally affect how companies operate, what taxes they pay, their employee relations, their safety standards, their impact on the environment, and a myriad of other government/business relationships. NAM has a policy supporting U.S. conversion to the metric system of weights and measures. It strongly supported P.L. 94-168 as it passed through the Congress and formation of the U.S. Metric Board. In a sample poll of nearly 1,000 NAM member companies reported upon in July 1979, 64 percent of respondents were in favor of the conversion compared to 27 percent against. The member companies polled covered the full spectrum of company size and variety of manufactured products.

The USMB study of research techniques for assessing the status of metric use (Ref. 7), concludes that the "Temptation is as great as it is misleading to concentrate on the institutionally visible aspects of metric use (planning, conversion budgets, grants for training). Most important are business and industrial changes -- new capabilities, marginal production changes, new supplier-customer relations--which may be relatively hidden from view."

Both the GAO and NBS metric studies (Refs. 1 and 8) addressed themselves to those issues and concerns that are also the province of the NAM. GAO reported that the strongest support for converting to the metric system came from State education officials, State government officials and the Fortune 500 industrial companies. Building and construction associations supported conversion but not as widely as the above groups. Small businesses were divided with slightly more being opposed to metrification than supporting it.

In GAO's survey of businesses' opinion on metrification, a total of 1900 businesses were surveyed regarding their views on metrification. Five hundred of these companies were

members of the Fortune 500, while the other 1400 were classified as small businesses. The information relating to small businesses gathered by the GAO is not noted here but referred to rather in The Small Business Constituency, Section (A-8).

GAO noted that the largest companies in each industry usually support conversion. The majority of companies in all industries viewed metrication as being inevitable for their respective industries. The large business respondents believed the Government should encourage conversion through purchase of metric goods. The large businesses generally supported conversion to the metric system although they were divided over the relative advantages and disadvantages of conversion. Nevertheless, a majority of the large business respondents believed the advantages to be greater than the disadvantages.

The conclusions reached in the NBS Manufacturing study (Ref. 8) appear to parallel those noted above from the GAO report. The NBS report, however, appears more comprehensive and quantitative. This report indicated that in 1970 about 10 percent of U.S. manufacturing companies made some use of metric measurement units and/or metric measurement standards. The proportion of large companies that used the metric system was substantially higher (over 30 percent) than the proportion of small companies (less than 10 percent).

Metric users among manufacturing companies in the United States have experienced both advantages and disadvantages of metric use. Simplified specifications, cataloguing, and records; improved intracompany liaison and records; and training of personnel were cited as the chief advantages. Difficulty in obtaining metric-sized parts and tools, dual dimensioning or duplication of drawings, training personnel, and more production items in inventory were cited as the most important disadvantages. About three-fourths of the metric user companies indicated that metric use was neither advantageous nor disadvantageous.

The attitude of manufacturers is mixed as to whether the increased use of the metric system in their own industry would be beneficial. More companies in total, by a small margin, are against increased use in their own industry rather than for it. However, larger companies, which tend to be more experienced with the metric system, are more favorably disposed toward it so that a measure based on the economic importance of respondents in terms of value added by manufacture would favor increased metric usage in their own industry.

Many of the research reports produced by the USMB relate to concerns that are similar to those of the National Association of Manufacturers. The major conclusions and recommendations of these reports are summarized below. However, it should also be noted that the information presented elsewhere in this research summary would be of interest to the NAM, especially the sections which deal with small business, workers, educators, and consumers.

The 1979 USMB status of the Fortune 1000 report (Ref. 9) indicated that 32 percent of present sales of the largest U.S. firms were of metric products, considerably more than indicated at the times of the GAO or NBS reports. The GAO report was undertaken in 1976 and completed in 1978 while the NBS studies were completed in 1971. The USMB report indicated that limited planning and coordinating activity was evident, not only within individual firms, but also among the industry groups surveyed. Further, the prevailing disposition was found to be a "wait and see" attitude - coordination on metric matters between suppliers and customers appeared to be limited. Impediments continued to hinder some industries. This affected both the pace and degree of metrication. The most frequently stated reasons for conversion related to international acceptance (see Section A-14), and meeting customer demands. When the respondents were asked what a realistic time frame was for their companies' conversion, the median time frame was found to be ten years or less. Nevertheless, it was considered likely that it might never be implemented over all industries.

A similar independent study (Ref. 10) published in the Spring of 1980 surveyed 750 corporate organizations selected randomly from a population consisting of the Fortune 1000 industrial firms. The report (Metric Conversion: Where We Are and Where We're Going) concluded that lukewarm, go-slow attitude on the part of industrial firms is evident. Although there is support for the concept of conversion, there is some lack of commitment to the action. The impression one derives is that American industry is waiting for some impetus. This presents a dilemma for business and government policymakers: If conversion is left on a voluntary basis, as it is now, the process may be agonizingly slow and its completion uncertain. However, if conversion is made mandatory, the reaction may be so counter-productive that more problems would be created than solved. Clearly, the road to metrics, while paved with good intentions, is turning out to be a slow and doubtful route.

The USMB's "Impact of Laws on Metric Conversion" study (Ref. 11) reached several conclusions and recommendations

related to the concerns and interests of the NAM. Interviewees believed that laws and regulations did not represent meaningful impediments to metric conversion. However, they believed that at the Federal level the Fair Packaging and Labeling Act of 1966 represented the law of concern to most industry groups. The study indicated that the antitrust laws cause concern to the extent that collaboration among competitors in the development of industry metric conversion is viewed as being in restraint of trade.

The study also concluded that there was no meaningful correlation between a corporation's metric planning and the nature of its perception that legal impediments exist. The study found that the laws that do concern representatives of the Fortune 1000 are evenly divided between the Federal and State/local levels of government. The firms participating in the study had not been involved in company or industry-wide lobbying efforts concerning metric conversion, hence there was no relationship between lobbying efforts and a perception of legal impediments. Most of the firms surveyed said that they would support efforts by industry to change the perception of legal impediments.

A finding in this study disclosed the perception that impediments really do not exist to any great extent. This confirmed the earlier findings of the USMB's study of Metric Measurement and Legislation (Ref. 12) which stated no legal barriers to metrication exist. The two areas of greatest concern were the antitrust laws and the building codes (see Section A-9, construction constituency). In one instance the problem maybe fear of the unknown; in the other it is that the consideration is real. A number of corporations have had excellent experiences in removing the perceptions and, in some instances, the actual impediments to metric conversion. To help in alleviating the fear of antitrust issues, The Board produced an antitrust handbook for metric planning and conversion (Ref. 13).

As a result of the Impact of Laws on Metric Conversion Study (Ref. 12) and other studies addressing legal concerns (Refs. 11, 13 and 14), the Board felt that similar approaches to the antitrust handbook should be explored for sponsorship regarding the concerns with building codes, fair packaging and labeling, and weights and measures.

In the Metric Measurement and Legislation study all aspects of metric measurement and legislation were reported upon including the U.S. metric environment, the legislative and regulatory environment, possibilities for effective metric change mechanisms, and alternative metric change strategies. A summary of the metric change options is presented in Table A-1. The table also assesses the relative

TABLE A-1

SUMMARY OF METRIC CONVERSION OPTIONS

OPTION	APPROACH	COMMENT
OPTION 1 o Most Effective	- Amend PL 94-168 to allow for sector metric plans effecting legal changes at both Federal and State level.	o Only one Legislative action required. o Favored by Industry o Provides for consensus o Provides for uniformity at Federal and State levels o Raises Federal Pre-emption issues
OPTION 2 o Effective	- Amend PL 94-168 to allow for sector metric plans effecting legal changes at only Federal level. - Congress enacts Federal version of Uniform Metric System Procedure Act.	o One or two legislative actions required o Allows for consensus at Federal and State level o Provides for uniformity at State level o Reduces Federal preemption issue
OPTION 3 o Less Effective	- Amend PL 94-168 to allow for sector metric plans effecting legal changes at only Federal level. - USMB encourages State to adopt Uniform Metric System Procedures Act.	o 51 legislative actions required o Allows for consensus at Federal level only o No uniformity at State level
OPTION 4 o Least Effective	- Case by case Federal legislation. - USMB encourages States to adopt Uniform Metric System Procedures Act.	o Unlimited Legislative actions required o No consensus o No uniformity at State level

effectiveness of each option, summarizes each approach and provides comments on the approach.

However in the USMB report to the Congress, Providing a Metric Option (Ref. 14), the Board found given the current pace of voluntary conversion activity the available mechanisms were not sufficiently strained to require additional legislative action. Further, the report found that there was not a significant amount of existing laws and regulations at all levels of government to present legal barriers to voluntary conversion efforts.

Many of the reports published by the Office of Research are related either directly or indirectly to concerns of the National Association of Manufacturer. These reports shall only be referred to here in passing. Greater detail resulting from these research results will be noted elsewhere. For example, the small business studies (Refs. 15, 16, 17, 18 and 19) of the U.S. Metric Board touch on the concerns of small manufacturing enterprises. However, the relevant data dealing with small businesses will be noted in Section A-8, the small business constituency of the Board.

Although the costs of workers' tools, training and the worker safety issues (Refs. 3, 4, 5 and 6) relating to both small and large manufacturing concerns are tangentially relevant to this constituency, these topics and the associated research results fall neatly and completely into the AFL-CIO constituency (Section A-6).

This approach is also pursued with the U.S. Metric Board studies related to consumers (Refs. 20, 21, 22 and 23). The consumer studies which relate to concerns of the NAM include (1) the metric conversion of distilled spirits containers, (2) the supermarket survey, (3) U.S. Metric Board's consumer study and (4) the conversion of retail fuel pump computers to sale by the liter. These studies are relevant to large and small manufacturing concerns. The factors relate to market concerns and perceptions, implications for international trade, the costs and savings of the conversion process, etc. However, these topics are more concisely and coherently covered in the consumer constituency, Section A-12.

Finally, the Conversion Data Project, (Ref. 24) presents an extensive discussion of the status of metric conversion activities for selected industries. This study is directly related to concerns and interests of the NAM. This report provides an extensive information base on the progress, difficulties, and outlook for metric conversion of selected two, three, and four-digit Standard Industry Classification

industry groups. This information has and continues to be used by the Office of Research, others at the USMB, and the community at large in preparing and implementing the USMB's efforts to assist those industries needing information regarding metric conversion. Data for each industry group was presented both separately and in a cross industry data summary. More details regarding this study, including its relevance to interests and concerns of the NAM will be found in Appendix B under the mandate perspective of assessing the status of metrication in the U.S.

A-5: United States Chamber of Commerce, Retailers and other Commercial Organizations

Discussion of research results relevant to this constituency will be limited for the most part to large non-manufacturing businesses which are represented by the U.S. Chamber of Commerce or other commercial organizations. Many of these businesses are in the retailing sector of the economy. This limitation is made to avoid repetition of the information presented since data related to manufacturing concerns has been referred to in Section A-4, above (under National Association of Manufacturers) and results primarily to small businesses are discussed in Section A-8.

The GAO report (Ref. 1) is not relevant to this section since it only contains one section which surveys the opinions of businesses on metrication. The views of small business is treated in Section A-8. The large corporations surveys were limited to members of the Fortune 500, the 500 largest companies that derive more than 50 percent of their revenues from manufacturing and/or mining. These were dealt with in Section A-4.

NBS's U.S. Metric Study contains one volume dealing with non-manufacturing businesses (Ref. 25). Among the non-manufacturing sectors of the economy addressed were wholesale and retail trade. The total of all the non-manufacturing industries surveyed by NBS includes about 65 percent of the total U.S. employment and represents a wide variety of economic activities. The major conclusions of this study were: (1) accurate knowledge of metric system characteristics was not universal; (2) there were few significant differences in opinion among companies grouped by three size categories (the largest organizations tended to be more favorable toward adoption of SI, to feel a need for a longer change over period, and more often to favor a mandatory national program of metrication established by legislative action, than were smaller companies); (3) a majority of the respondents foresaw no particular difficulty in converting to the metric system; and (4) about 26 percent of the total sample was against increased metric

usage within their own companies in case of a national metric changeover.

The USMB's Impacts of Laws on Metric Conversion study (Ref. 11) indicated that for all of the businesses surveyed, including the large business retailers of interest in this section, interviewees believe that laws and regulations do not represent meaningful impediments to metric conversion. Other conclusions and recommendations derived from this study that are related to large non-manufacturing business were previously noted in Section A-4 dealing with the NAM. Similarly, USMB's Metric Measurement and Regulations study (Ref. 12) also is applicable to large non-manufacturing enterprises. The results of the study have already been noted.

The U.S. Metric Board's small business studies (Refs. 15-19) are relevant to this constituency, especially retailers and other commercial organizations. These studies will be treated at length, in Section A-8.

A-6: American Federation of Labor and Congress of Industrial Organizations

The GAO report (Ref. 1) discussed briefly the issues of training and metric tools. The report concluded that training and metric tools would be required for workers if metrication should occur in the U.S. Further, the GAO concluded that almost every worker would be affected to some extent if the U.S. were to convert to the metric system. Although they felt that the full impact would not be known until conversion occurred to a greater degree, the major potential issues appeared to be metric training and tools for employees. Workers, to varying extents, would need to learn a new measurement language, and some workers would require tools. Worker productivity might also be affected.

The GAO reported that the AFL-CIO also expressed concern that metric conversion could have an adverse impact on worker income and job security. The union believed that large conversion costs, employee confusion, shortage and scheduling problems, increased imports, equipment adjustments, and difficulty in interfacing, mounting, and connecting metric and customary equipment could increase unemployment and temporary layoffs.

The National Bureau of Standard's reports do not treat specifically the concerns of workers although they do discuss issues that are of concern to workers such as international standards, education and consumers.

The U.S. Metric Board's Office of Research has conducted a series of studies (Refs. 3-6) directly related to the labor constituency. These reports address the topics of worker tools, metrology sensitive occupations, and worker safety. In these studies little in the way of Federal assistance for tool replacement or training was uncovered. The IRS code, however, can be used by employers, independent craftsman and itemizing workers. It was observed that six quantities (length, mass, volume, area, temperature, and pressure) were estimated to be used by more than 10 percent of occupations reviewed.

The results of the Metrology Sensitive report (Ref. 3) fell into two groups. One was related to the metrology-sensitivity of U.S. occupations; the other related to the area of legislation, regulation, assistance programs and Canadian experience relevant to metrication impacts on tool and training practices.

It was found that 54 percent of the workforce was not sensitive to measurement change (i.e., making measurements; using measurement specified items; and manipulating measurement specific information). Occupations which were measurement sensitive account for 30.5 percent of the workforce; occupations dimension (or specification) sensitive comprise 12.3 percent of the workforce; and occupations process sensitive comprise 19.2 percent of the workforce. These percentages added to more than 100 percent because of the existence of occupations with more than one form of metrology-sensitivity.

All sensitive occupations are subject to possible training impacts but are differentiated by tool cost impacts. Measurement sensitive occupations may be required to replace or add measuring tools such as tapes, gauges, and scales. Occupations having dimension sensitivity may be required to replace or add tools such as wrenches and cutting tools. Occupations which were purely process sensitive have no potential tool impacts. Process sensitive occupations are largely distinct from the other two types.

In the worker tool and training study (Ref. 5) it was concluded that workers' individual tool costs varied considerably (\$100 to \$1000). It was noted that often the employer pays for metric tools although some employees must pay for all of their own metric tools. Tax deductions were often not utilized by individuals. Workers who buy their own tools (metric) typically purchase such tools incrementally over a number of years. Further, the methods used by individuals to purchase personal tools vary considerably, depending upon the occupation, the employment situation, and habits of the individual. Because of the variety of

approaches taken in developing and presenting metric training programs, the cost varies substantially. However the employer usually pays for metric training.

Additional conclusions reported in the study follow. The length of metric training programs varies substantially; employees often experience anxiety prior to metric training programs; some employees receive no formal metric training; and considerable duplication of training effort exists. Metric change has not impacted career issues. Elderly workers experience anxiety. Collective bargaining is addressing metric topics. Some potential safety problems exist. Productivity may be impacted by metric change. Confusion exists regarding the U.S. Metric Board's conversion activities. Dissemination of educational materials is minimal. Labor involvement in the metric conversion process is essential to its success.

As a result of the study's findings and recommendations, the Board informed the President and Congress of the unequitable burdens and suggested possible forms of relief be considered. The study also found that potential safety hazards may exist when metric conversion occurs. Because of this potential problem, the Board initiated research to investigate the safety issues which may exist for certain occupations (Ref. 6).

The safety study focused on identifying the possibility of increased safety hazards in specific job tasks that require the use of measurement units. In the study, no metric hazard experience was identified. In many instances, hypothetical scenarios were provided that characterized the potential for hazard, but none of these could be substantiated with actual experience.

An increased exposure might occur when particular jobs and their job tasks are going through the transition from customary measurement to metric measurement. Specific occurrences related to the tasks include: (1) worker judgment is exercised in using measurement; (2) communication of a measurement value between two workers; and (3) conditioned response in emergency situations involving measurement parameters.

Well planned metric change programs reduce hazard potential. Industrial safety programs can reduce metric hazards. Involvement of professional safety experts in metric planning, metric training programs, and procedural analyses can reduce the potential exposure to hazards resulting from metric change.

Metric safety issues are unresolved in the aviation industry. At the present time, the aviation industry is

experiencing increased usage of metric measurement at the international level. In many countries the use of metric instrumentation is becoming commonplace. In contrast, within the United States, all the aviation industry is equipped with inch-pound instrumentation. This is leading to increased requirements for airborne conversion as U.S. aviators fly in a metric measurement environment outside of the United States and as metric oriented aviators fly in the U.S.'s customary measurement aviation environment. Many safety issues related to aviation's adoption of metric measurement can be identified in U.S. periodicals, but these have not yet been resolved nor has a comprehensive aviation conversion plan been developed and endorsed by the industry.

The Worker Tool and Training study (Ref. 5) also recommended that the U.S. Metric Board should investigate the feasibility of establishing a metric training materials clearinghouse service. The value of this service in future years would be that it would reduce the continuous duplication of effort that appears to be going on in the development of metric training materials throughout the country. However, due to severe budgetary cutbacks this activity was not initiated.

A-7: National Governors Conference, the National Council of State Legislatures, and Organizations Representative of State and Local Government

Both the GAO and the NBS addressed the interests and concerns of State and local governments as they relate to metrication. The GAO report stated (Chapter 23) that, while State governments support metrication activities, they generally remain inactive and that this support is somewhat tentative. The GAO concluded that the policy expressed in P.L. 94-168, that of having the United States coordinate and plan the increasing use of the metric system, did not appear to be enough of a Federal metrication commitment to cause the States to convert their operations.

The GAO further concluded that for the most part the States have adopted a wait-and-see attitude. States agreed that the metric system might be good for multinational corporations in improving their world trade and an easier and more logical system for everyone. However, their deep involvement in conversion would only come when the actions of industry and the U.S. Government gave stronger and more immediate reasons for a change. At that time, GAO felt that affected State laws and operations could be converted as needed (see below for more recent USMB research results regarding state laws and metrication).

The GAO did not believe it was reasonable to expect States to initiate the imposition of a new system of measurement on intrastate affairs without strong incentives. In interstate affairs, GAO thought that careful coordination by the Federal Government would be necessary to avoid confusion and disruption in the regulations of commerce and other matters. GAO believed, finally, that the States were looking for some form of leadership from the Federal Government but had not yet received it, particularly with regard to a firm national commitment as to which system - metric or customary - the United States is to predominantly use.

In distinct contrast to the attention paid to State constituency by the GAO, the NBS report Testimony of Nationally Representative Groups (Ref. 26) deals with this group only superficially. It is not referred to at all in the summary NBS report (Ref. 27) and dealt with only briefly in the Testimony report. Among the many groups invited to submit inputs to the NBS study was the National Governors Conference. No submission was made, however.

There were several submissions by organizations representative of more local government, viz., (1) The International City Management Association, (2) The National League of Cities, (3) The U.S. Conference of Mayors, and (4) The National Association of Counties. In the case of the ICMA a report was based on a study of five typical cities, while a survey of two typical urban counties was used to represent the NAC. The consensus of the groups representing cities was that it would be difficult to identify benefits of metrication for cities. The county group felt prepared to cooperate in the anticipated change, but not to innovate. They viewed themselves as consumers, not producers.

The USMB's Impact of Laws on Metric Conversion Study (Ref. 11) confirmed GAO's, as well as other legal research efforts (Refs. 12, 13, and 14), beliefs that laws and regulations do not represent meaningful impediments to metric conversion. This study found that, for a commodity packaged for export, the declaration of quantity in most states' weights and measures laws may be expressed in terms of the metric system. This study observed that laws that do concern representatives of the Fortune 1000 are evenly divided between the Federal and State/local levels of government.

Similarly, in the USMB's Report of Hearing on The Conversion of Retail Fuel Pump Computers for Sale by the Liter (Ref. 23) it was found that there were no significant legal barriers to the sale of fuel by the liter. Further, it was

noted that the interested parties were willing to participate and contribute in the hearing process.

In the report, A Study of Metric Measurement and Legislation (Ref. 12), it was stated that legal barriers do not exist, based on the analysis of the nature of measurement units as they are imbedded in legislative and regulatory material. However, this study indicated that there were many cases where measurement units in such material appear on the surface to present legal barriers to the use of metric units or to the introduction of metric sizes. One such example cited was the Method of Sale laws enacted by many states. These laws originated as a means of protecting the consumer against pricing deception by standardizing the sizes of consumer products, typically dairy products, meat products, and other basic food stuffs. The study's legal advisory panel, however, concluded that Method of Sale laws do not present legal barriers to the introduction of metric sizes, an opinion that is supported by the Department of Justice. A Department spokesman has stated that any state law which tended to limit the sizes of products available to consumers was considered anticompetitive by the Justice Department.

The study concluded that whereas no legal barriers to metric units exists, the need for an effective change mechanism still exists. If the thousands of legal deterrents that exist at all levels of governmental laws and regulations are left to be changed on an individual basis, they would represent a significant potential impediment to the voluntary conversion program as defined by P.L. 94-168. The report recommended that the USMB provide guidance for Federal and state legislative bodies regarding the incorporation of metric and customary units in all new legislation. The report indicated that state governments, in particular, are interested in receiving positive guidance from the USMB regarding the appropriate use of metric units and the incorporation of metric units in legislative and regulatory materials.

In its report to the Congress - "Providing a Metric Option" (Ref. 14), the Board stated that there was no present need to provide a new structural mechanism. The report found that existing laws and regulations at all levels of government do not constitute significant legal barriers to voluntary conversion efforts and most of the required legal changes can be accommodated through administrative rule-making rather than legislative action. The report further stated that the voluntary conversion activity currently underway is not yet of significant magnitude to strain the effectiveness of available mechanisms.

A-8: Organizations Representative of Small Business

The General Accounting Office surveyed 1,400 small businesses (Ref. 1). The GAO concluded that most of the small business respondents did not know the U.S. policy on metric conversion. In contrast, most large business respondents did know. Over 40 percent of the small businesses (in contrast to 13 percent of the large businesses, see Section A-4) believed incorrectly that conversion is mandatory.

The largest percentage of the respondents, both large and small, saw little or no price changes in their products as a result of metric conversion. A considerable number did see some price increase, however.

Most of the respondents believed that the Federal role in conversion should be that of coordinator, planner, and counselor, rather than enforcer. Whereas the large business respondents believed the Government should encourage conversion through purchase of metric goods. Of the small business respondents expressing an opinion, most opposed this position.

Most of the small businesses believed they could convert to the metric system within 10 years; a considerable number indicated they could convert in less than 5 years. An overall time frame of 15 years would allow about 80 percent of the firms questioned to convert within an optional period of time. Most respondents also believed that the industry should be involved in establishing target dates for conversion.

More of the small business respondents believed they would not need assistance to finance metric conversion than believed they would. However, a considerable number did not know.

The National Bureau of Standard's study, summarized in A Metric America (Ref. 27), does not treat specifically the concerns of small businesses and the organizations representative of small business. However, two of the NBS reports do treat the concerns of the manufacturing industry (see Section A-4) and non-manufacturing business (Ref. 25).

Research efforts by the U.S. Metric Board have included many studies of relevance to small businesses and organizations representative of small business. These reports included: (1) the USMB's small business studies, some of which are small manufacturing concerns (Refs. 15-19); (2) the Board's studies which address the topics of worker tools and metrology sensitive occupations (Refs. 3-6); and (3) USMB studies related to consumers (Refs. 20-22), the

ultimate purchaser and user of the end products of manufacturing concerns. These directly related USMB studies are discussed below. Those studies peripherally related such as worker tools and consumers are discussed in Sections A-6 and A-12, respectively.

The survey of small business study (Ref. 15) noted that there is a modest but significant amount of metrication with more emphasis on hard metric products than soft or hybrid metric products. This study also noted that although problems have been encountered by firms that have converted, the problems seem to have been overcome within the firm's resources. Further, trade or business associations are not seen at present as vehicles for metric conversion planning, nor does there appear to be any significant amount of metric conversion planning underway. Finally, the study noted that for the majority of businesses, the cost of converted products is generally about the same as the cost of customary products. Also, conversion has taken place principally because of demands from customers, suppliers, or the particular industry as a whole. To the extent the following two recommendations relate to small business engaged in manufacturing they are relevant here: (1) because small business does not see itself as well represented but feels it should be represented, efforts should be made to provide information on the costs and benefits of conversion to trade and business associations, especially those with small business constituencies; (2) many small businesses believe the U.S. Metric Board has the enforcement power in the conversion process. The Board therefore needs to clarify its role as a coordinator of a voluntary process.

The Search for Small Business with Investments in Metric Production study (Ref. 16) related to the costs and benefits of conversion to small businesses. Although this study listed no recommendations, many major conclusions were reached. Most small businesses, for example, convert part of their production to metric because of customer demands. It was also noted that few companies convert more than a small percentage of their production to metric.

The report concluded that most companies respond to metric requests by converting the requests into customary units and producing, using conventional machines. The study found that conversion has cost small businesses very little. Costs have ranged between \$1,000 and \$5,000. Conversion occurs on the margin as changes occur, and metric is often spurred by the need to repair, modify, or replace foreign machinery. It was considered noteworthy that metric activity is greatest in the machine and fabricated metal products industries, which make products for other industries.

Large corporations often assist their small business suppliers in meeting their metric demand. Also it was concluded that there was little interest or awareness in sector planning related to metric conversion.

Legal impediments to metric conversion have been discussed previously in the subsections above dealing with the National Association of Manufacturers and the U.S. Chamber of Commerce, retailers, and other commercial organizations. Of special interest to the constituency here addressed is the conclusion reached that interviewees believed that laws and regulations do not present meaningful impediments to metric conversion. Also, most of the firms interviewed would support efforts by industry to change the perception of legal impediments. Where impediments are perceived, the two areas of greatest concern are the antitrust laws and the building codes. In the first instance the problem is fear of the unknown; in the other it is that the consideration is real.

A-9: Representatives of the Construction Industry

The GAO report (Ref. 1) devoted a significant amount of attention to the construction industry. The building and construction industry is one of the largest contributors to our gross national product (9 percent in 1976) in addition to the large amounts spent yearly for maintenance and repair. In January 1978, four million workers were employed in construction performed under contract.

Metric conversion in the industry was observed by the GAO to be taking place at a slow rate, if at all. The reasons cited were: (1) no compelling reasons for converting; (2) uncertainty in the industry toward national policy and Federal commitment to conversion; (3) concern in parts of the industry about the costs and lack of benefits; and (4) the difficulty of individual firms or segments of the industry to act alone in metric endeavors. Much of the industry is passive toward metrication.

The reasons cited why the industry has no compelling need to convert were fourfold: (1) since it is primarily domestic, there is no need to export and the industry does little export trade; (2) there is no difficulty obtaining customary materials, (3) customers are not demanding construction in metric; and (4) conversion is voluntary.

The GAO concluded that although much of the industry considers metric conversion to be inevitable, it probably will not convert, at least not in the near future, unless it is mandated or the Federal government establishes a clear national policy to convert and plays a greater role in the conversion.

The NBS study for nonmanufacturing firms (Ref. 25) refers to the construction industry with much less emphasis than does the GAO. This NBS report gives a broad perspective of the kinds of problems which might arise in metrication, based on opinions from people in many different kinds of economic activity. However, it does not deal at great length with the contract construction industry.

It should be noted, that the construction industry is extremely fragmented and, for the most part, its members are relatively small businesses. Thus, the data presented for the Small Business Constituency (A-8) also pertains to the construction industry. Similarly, Section A-6 relating to workers would be related to those workers in the construction industry. This section, however, relates specifically to the construction industry and its workers.

The report, the Impact of Laws on Metric Conversion (Ref. 11) noted that the perception of those interviewed is that laws and regulations do not represent meaningful impediments (barriers or deterrents) to metric conversion. However, they acknowledged that certain laws are taken into consideration by firms as a factor in the planning process. For the industry-perceived laws impacting conversion, the building industry's only concern was with building codes. Building codes are designed primarily to protect the public from fire and other safety hazards. The codes consist of standards and specifications. Often the codes are administered by local governments, but are in fact formulated and enforced through state governments (see Section A-7 for related information regarding this constituency). The types of standards and specifications covered in the codes relate to the type of construction, acceptable loads and stresses, and the quality of materials. The requirements are almost always expressed in customary units.

The report concludes that the building codes are one of the two areas of greatest concern (the other is the antitrust laws), but were not viewed as legal barriers per se. The major concern about the various requirements of the building codes is based on real circumstances. It is conceivable that major changes in building codes will be costly.

The USMB's study of metric measurement and legislation (Ref. 12) made broad mention of building codes and the construction industry and, reinforces the comments from the Impact of Laws Study (Ref. 11).

A-10: National Conference on Weights and Measures and Standards Making Organizations

The General Accounting Office report (Ref. 1) contains an entire chapter dealing with engineering standards, including the views of standards writers such as American National Standards Institute, the American Society for Testing and Materials, the American Society of Mechanical Engineers, and several other groups.

The GAO concluded that metrication was not considered necessary to increase standardization, rationalize existing standards, enable reviews of existing standards to see which are outmoded and should be eliminated or revised, and improve technology. Metrication could cause standards organizations and industry to take a more penetrating look than they otherwise might, but other events could cause these to occur under the customary measurement system.

GAO further concluded that metric conversion would require an evaluation of measurement-sensitive standards. In some cases soft conversion would be made because it was not practical to make dimensional changes to the items involved. Soft conversion is considered by some to be a potential waste of resources because no physical change occurs in the standard or eventual product.

A few standards in use in the U.S. have been converted, and most of the standards organizations contacted by GAO have established policies and are moving slower than originally planned because conversion is not occurring as fast as some groups had expected.

The NBS' U.S. Metric Study Commercial Weights and Measures (Ref. 28) explored the probable effects of a metric change-over on commercial weights and measures activities. As part of this study the effects of metrication on state and local weights and measures jurisdictions were assessed.

The report strongly suggests that, in the event the U.S. should decide to convert to the metric system in commercial weights and measures, a coordinated program of metrication for this area should be established with a required date (or dates) for ending the use of customary units on package labels and commercial weighing and measuring devices. Leadership for the program, it was suggested, should come from the Federal Government and be coordinated through the National Conference on Weights and Measures (NCWM).

Some conclusions and recommendations resulting from several U.S. Metric Board research studies have related to the NCWM and standard's making organizations. The Impact of Laws

study (Ref. 11) indicates that, at the Federal level, the Fair Packaging and Labeling Act of 1966 represents the law of concern to some industry groups. Further, the study notes that most states provide in laws for a commodity packaged for export, that the declaration of quantity may be in terms of the metric system; otherwise customary units are required.

Two specific metric conversions (distilled spirits and gas pumps) provide information relevant to the NCWM and also to standards making organizations. Research studies concerning these two conversions were conducted by the Board. The metric conversion of distilled spirits containers studies (Refs. 20, 29, and 30) discuss the standards and rules relating to sizes and quantities. Because the alcoholic beverage industry is a regulated industry, the determination of acceptable metric sizes for new bottles was coordinated by the Bureau of Alcohol, Tobacco, and Firearms (BATF).

The Conversion of Retail Fuel Pump Computers to Sale by the Liter study (Ref. 23) reports on the participation of the NCWM in the USMB hearings. The NCWM testified as being on record as recommending that the long-range solution to retail motor fuel dispensers with obsolete unit price-computing capability is conversion to, or replacement with, metric equipment. The NCWM noted that hurdles will be encountered in converting to metric. These hurdles include: (a) planning and agreement on timetables to accomplish changeover, (b) education of all parties to the changeover, (c) coordination to minimize confusion and the duality period, (d) the need for a short-range solution with an appropriate cut-off date, and (e) possible Federal legislation to bring the long-term solution closer to implementation.

The NCWM stated that conversion would help allay inflation and that economic considerations on this issue were clear cut. However, it was noted that since the NCWM is a consensus organization, there are those within NCWM who differ with this consensus. NCWM noted that they have been on record as supporting voluntary metric conversion since 1971, when the metric study authorized by Congress was completed (The NBS Study; see Ref. 28).

In the USMB report Providing A Metric Option (Ref. 14), the National Conference of Weights and Measures was listed as one of a number of independent organizations which develop and promulgate uniform state codes addressing various subjects, including those which might relate to metric versions of model state laws. The report also discusses the way the NCWM might be of assistance in working with state governments.

The Metric Measurement and Legislation Study (Ref. 12) indicates that, while no legal barriers to metric units exist, the need for an effective change mechanism still exists. If the thousands of legal deterrents that exist at all levels of governmental law and regulations are left to be changed on an individual basis, they represent a significant potential impediment to the voluntary conversion program as defined in P.L. 94-168.

An example of the implications of the legal deterrent problem can be seen in the recent move to convert retail sale of gasoline to the liter, referred to above. This change represents only one element of the petroleum industry and is not representative of an industry-wide conversion plan. However, as a result of this change retailers who convert to sale of gasoline by the liter (at the pumps) will be faced with a continuing requirement to report monthly sales statistics, taxes, and other data on a gallon basis to satisfy the laws in 50 states. This represents a burden on the retailer that the whole petroleum industry would be faced with should they desire to convert the whole industry (refiners, wholesalers, distributors and retailers) to the use of liters and other metric units. Such problems can be anticipated and ameliorated with corrective, anticipated actions by the NCWM.

A-11: Educators, The Educational Community, and Organizations Representative of Educational Interests

The most comprehensive information available regarding educators, the educational community, and organizations representative of educational interests is presented in the GAO report (Ref. 1) and Volume 6, Education, of NBS's U.S. Metric Study Interim Report (Ref. 31). Both of these reports discussed formal, school-based education in the United States.

In this context, NBS concluded that the advantages of going metric in education are significant but not overwhelming; and, on the other hand, that the costs are not prohibitive and can be met largely out of normal expenditures. A conversion period of ten years was suggested as close to the optimum, but for that a national leadership and sense of purpose would be needed to completely benefit from metric conversion.

The GAO concluded that while some State and local educators were preparing to teach metric, many other sectors did not know if or when they should convert. When or if the need for metric education as the predominant system will arise, they further concluded, no one knew. They concluded, finally that timing was an issue which needed to be carefully coordinated.

The GAO felt that before additional funds for metric education are considered, the education effort should be further examined and put into phase with whatever metrication plans and efforts exist in industry, government, recreation, merchandising, and other sectors.

It should be noted, however, that outside of the formal education community much informal education, on-the-job training, and outreach learning takes place in American society. The USMB research reports make copious references to the capabilities of workers, consumers, homemakers, and others to acquire necessary metric information in these less formal educational contexts.

The Metric Usage Study (Ref. 32) makes reference to two cases where, for one company " . . . [no] personnel familiarity problems [were experienced] in its conversion to metric." Another company reported that " . . . no problems [were found] in training operators to use metric instrumentation and none had previously been anticipated."

In the survey done on the distilled spirits conversion (Ref. 20), the findings indicated both awareness and ignorance on the part of the consumers. For instance, while 73 percent of all spirit purchasers showed at least some evidence of an awareness of the existence of metric sizes, the majority of spirits purchasers were unaware of (1) the amount of contents in the containers they purchase, (2) any of the six allowable metric container sizes, or (3) the names of the six allowable metric container sizes.

In the survey of small business study (Ref. 15) the largest problem cited in converting to the metric system was making operational adjustments, (e.g., employee training). The study findings point to the need for an educational program aimed at informing the small businesses of the Federal government's responsibility in coordinating the conversion process. Again, this is an educational problem (small "e") - informal and not school related. Somewhat contrary to this conclusion was one reached in the Metric Usage Study (Ref. 32) which states that "working to metric presents no exceptional problems or benefits for small manufacturers."

The worker studies of the U.S. Metric Board (Refs. 3-6) also are related indirectly to educators and education - but informally for the most part. The main educational related conclusion of metrology sensitive occupations study (Ref. 3) was that 54 percent of the workforce are not sensitive to measurement change (i.e., making measurement, using measurement specified items, and manipulating measurement specific information). Also, all metrology sensitive occupations are subject to possible training impacts.

The Workers' Tools and Training study (Ref. 5) showed that the cost of metric training varies considerably, depending on whether existing training programs are available, what materials are used, and the time involved in conducting a training program. Many workers who were interviewed noted anxiety about having to learn and use the metric system. This is usually dispelled by the training programs. A considerable amount of duplication of metric training materials exists, caused by a lack of information regarding sources of such materials. This latter situation led to the recommendation that the U.S. Metric Board investigate the feasibility of establishing a clearinghouse service through which sources of metric training materials can be made known to the private sector. As previously noted, this activity was not initiated due to severe resource cut-backs in fiscal year 1982.

Of significance to the formal/informal aspects of metric education is a conclusion reached in the Research Techniques study (Ref. 7). The report states that "The temptation is as great as it is misleading to concentrate on the institutionally visible aspects of metric use (planning, conversion budgets, grants for training). Most important are business and industrial changes - - new capabilities, marginal production changes, new supplier - customer relations - - which are relatively hidden from view."

The Consumer Report (Ref. 22) indicated that considerable effort had been expended by the Board in developing sound educational materials and to establishing practices and procedures which permit consumer participation.

A-12: Consumers and Similar Constituencies

The GAO report (Ref. 1) devoted parts of several chapters to matters of concern to consumers. Such materials related to weather reporting, home appliances, and such matters. It also devoted one chapter of its report exclusively to the general public and consumer products.

The GAO concluded that consumer acceptance was one of the most crucial, if not the most crucial, areas involved in achieving a metrication program. They determined that few consumers had a clear understanding of the metric terms they would use in their daily lives. This was found to be especially true for persons who were older, had a lower income, were without much education, or belonged to a minority.

GAO further concluded that a majority of consumers did not favor converting to the metric system. Many saw no bene-

fits in converting. The GAO felt that if the U.S. were to convert, the Government would need to undertake public awareness programs. It was felt that these should be coordinated with conversion and promotional activities that take place in the public and private sectors. Both sectors should share the burden and would need to work together.

The GAO noted that metrication of many products could not be done on a voluntary basis. For example, many states have laws and regulations which require the use of customary sizes for products, such as bread, flour and butter. Most states also have weights and measures laws or regulations that tend to limit use of metric measurements. These matters have been referred to in other sections, especially Section A-10.

The NBS devoted an entire publication to discuss The Consumer (Ref. 33), a portion of the broad U.S. Metric Study. NBS's consumer study was directed to effects as they apply to the individual American. A portion of the consumer study involved a survey of attitudes and opinions of consumers and their level of knowledge of both the customary and metric systems of measurement. In another portion, experts presented views on the present impact of metrication on selected consumer activities and the possible future effects with no national program to increase metric use; or, alternatively, with a planned program of metrication.

The sample survey disclosed that a majority of consumers are satisfied with the customary system, that they know very little about the metric system, and that they could be expected to react with apathy and indifference to any planned conversion program. Those who did not react favorably to metrication gave as reasons, "inconvenience of a change," and "satisfaction with the present system." However, many of them admitted that metrication did have some advantages. Those who thought it was a good idea to change explained, "It is used by most other countries," and "It is a decimal system and easier to use."

The fact that a majority of the respondents were unable to name a single metric measure, and relatively few were familiar with either the relationships within the metric system or the relationship of metric units to customary units, suggests that much of the resistance to possible conversion stems from a lack of knowledge of the metric system. This was corroborated by the fact that those who were familiar with the metric system generally favored conversion, emphasizing the advantages and minimizing the disadvantages.

The level of knowledge of the metric system was apparently related to the educational level and to the age of the

respondent. Young people and highly educated people generally were more knowledgeable. Respondents seemed more familiar with prefixes and the relationship of base units and subunits in the metric system than with the relationship of metric measures to customary measures.

Experts submitting papers in selected areas of consumer concern verified that customary units and standards are used almost exclusively in consumer activities. They reported that the consumer is generally satisfied with the customary system and is little affected by the increasing worldwide use of the metric system. In many situations the consumer is totally unaware of the fact that a purchased item may involve metric language, components, or standards.

In the report, particular emphasis was directed to the lack of standardization in areas such as retail clothing and foods, and the promulgation of unsystematic and confusing practices, especially in consumer product information. To some consumers this situation is confusing and frustrating. For example, ready-to-wear clothing is offered to the consumer in a proliferation of illogically conceived sizes, and, similarly, processed foods are packaged in such a variety of sizes as to make price comparison almost impossible.

The experts almost unanimously agreed that conversion problems and costs would be confined to the transition period, and once completed, the advantages would outweigh the costs and inconveniences of the changeover.

Some of the direct advantages mentioned were simplification of calculations, elimination of ambiguities in measurement units (e.g., dry and liquid pints and ounces), and increased facility in foreign travel. Metrication was also visualized as the opportunity and possibly the incentive to introduce improved standards for clothing sizes, simplification of package and can sizes, elimination of confusing practices in consumer product information, and possible standardization at the international level.

There was unanimous agreement that the major disadvantage of planned metrication would be a psychological one of adjustment. Successful conversion would require a massive program of public education.

Although many efforts of the U.S. Metric Board related indirectly or referred obliquely to consumer matters, four studies touched more directly on the metric effects on consumers.

The USMB's study of metric conversion of distilled spirits containers, reached several conclusions relevant to

consumers (Ref. 30). Those conclusions not noted earlier include: (1) the most effective options for USMB are those which elicit the positions of interested and affected parties and publicize the results; (2) USMB's planning guidelines are essentially adequate to support USMB's options for safeguarding the interests of all parties in conversion planning; and (3) conversion is an activity which occurs within the context of the market place and private interests.

The supermarket survey of metric labeling (Ref. 21) has just recently begun and no results, conclusions, or recommendations related to this constituency are yet available. It is clear, of course, that results of this study will be quite relevant to this constituency.

USMB's report of retail fuel pump computers (Ref. 23) is also relevant to consumer interests. To the extent major conclusions related to consumers have not been noted previously in this report they are as follows: (1) there must be adequate information at the pump to allow unit price comparisons; and (2) the interested parties in the conversion of retail fuel pump computers to sale by the liter are willing to participate and contribute in the hearing process.

The USMB consumer report (Ref. 22) concluded that USMB's responsibility to serve consumers' needs has been acknowledged in every guiding document defining the agency's mission, from the Metric Conversion Act of 1975 to the Private Sector Metric Conversion Planning Guidelines and Principles and to the Final Consumer Program. The Board's ideological commitment to full public participation is also apparent in its willingness to meet with consumers in public forums for a free exchange of ideas.

It further stated that while USMB has devoted considerable effort to developing sound educational materials and to establishing practices and procedures which permit consumer participation, the agency still lacks a mechanism for serving consumer needs in a consistent, focused and well-coordinated manner. Having developed a sound consumer program, the next essential step is to allocate the staff and financial resources necessary to carry it out. Experience to date demonstrates that an ad hoc approach is not adequate to bring consumers into the decisionmaking arena.

The USMB consumer report presented a total of 32 recommendations and were discussed in greater detail in Sections III through V of the consumer study. Six of these recommendations related to the identification of and keeping a

list of knowledgeable consumer participants. Specific methods for doing this were listed. Five of the recommendations dealt with consumer participation in the conversion planning process and three with consumer participation at Board meetings and public forums. The remainder related to responding to public mail (seven), the adequacy of educational materials (ten) and organizing for consumer participation (one).

A-13: Federal and Related Constituencies

The GAO report devotes an entire chapter to the activities of the Federal Government as they impact on metric matters (Ref. 1). The GAO concluded that Federal Government metrication activities varied widely, but noted no consistent approach to conversion. GAO stated that metrication did not appear to be a high-priority item with the Federal agencies. Only 12 of the 26 agencies contacted by GAO had formalized metric policies, and these policies generally called for the agencies to respond to industry demands and not to lead.

The GAO felt that officials of the Federal Government agencies generally expected no specific benefits from metrication. If industry benefited from conversion it was assumed that the Government would benefit. Further, the GAO believed that a vast array of laws, regulations, and other requirements would have to be reviewed to ascertain the impact and type of change. Several agencies indicated that they were looking to the Congress, the President, or the U.S. Metric Board for guidance on what metrication actions they should take.

Further the study noted that some agencies, such as the Department of Agriculture, believed that metrication is mandatory and have taken aggressive steps to convert some operations which the public has disapproved. They find that the Metric Conversion Act of 1975 does not require anyone, Government agencies or the private sector, to convert. The Metric Act does not alter existing laws or regulations, and agencies must have existing authority or seek authority to require conversion.

Metrication by the Department of Defense is being driven by a desire for standardization, particularly with NATO countries, and a belief that metrication is inevitable. It is being impeded by a policy of nonadvocacy and a firm resolve by Defense not to pick up industry's total costs of conversion.

Measurement is an integral part of many activities and projects within Government. Without specific direction to

convert its activities, the GAO found that the Government may be frustrating industry plans. Other nations which are committed to conversion found that a strong government commitment was necessary to accomplish conversion.

The GAO recommended that the Office of Management and Budget:

- (1) Clarify for Federal agencies what they are expected to do in regard to planning and coordinating any increased use of the metric system;
- (2) Ensure that Federal agencies establish policies consistent with the intent of the Metric Conversion Act of 1975 and inform the private sector of Federal metrification plans whenever appropriate;
- (3) Ensure that Federal agencies convert regulations or mount other metrification activities when the initiative comes from the sectors which will be affected--industry, the states, and the general public. Federal agencies should only initiate action when they can demonstrate that such action is in the Nation's best interest; and
- (4) Require Federal agencies to inform the public of the impact of those conversion actions that affect them and hold public hearings to obtain their comments which should be considered in any final determination on such actions.

Two of the NBS U.S. Metric Study reports relate directly to the Federal constituency. These reports are Federal Government: Civilian Agencies (Ref. 34) and Department of Defense (Ref. 35).

The civilian agencies report found substantial expectation of increasing problems in the Federal establishment with continuation of a laissez-faire policy toward metrification, and widespread feeling that a coordinated national effort to increase the use of SI measurement units and engineering standards in the U.S. is desirable. A broad consensus of the Federal agencies and responding subunits expect that the long-term advantages of such a move would clearly outweigh any short-term disadvantages, even including the substantial costs that would be involved during the conversion period.

The study noted further that the conversion level of metric system use in this country had already seriously affected two areas of responsibility of the Federal establishment; the functions of the U.S. Coast Guard with respect to ship-

building (verification of compliance with safety and other standards), and the area of automobile safety. In the latter case the influx of metric-dimensioned foreign vehicles and components is requiring special tools for servicing and special blueprints for safety standards. Slightly over one-third of the 57 agency responses in the "area of national responsibility" part of the study expected increasing measurement-related problems, which, in the absence of a concerted national metrification effort, would range up to substantial or serious with regard to their area of responsibility.

Of these 57 agency respondents, 28 saw U.S. metrification facilitating the activities within their areas of responsibility and their interactions therewith, 31 favored increased U.S. metrification (most endorsing a coordinated national program), and only one opposed any national program.

The Department of Defense study (Ref. 35) reached two major findings:

- (1) The added cost to maintain constant mission capability while converting to the metric system is estimated to be approximately \$18 billion. The major financial impacts of converting to metric measurements will involve additive costs associated with the areas of design, development, procurement and support of new systems, publication of technical data, training of personnel, and storage generated by metrification.
- (2) The metrification process will impact the operational capability of the military forces. For example, changes or revisions would be needed for
 - a. Computer programs for data systems,
 - b. Installed equipments, supporting equipments, and documentation for operational systems
 - c. Communications procedures pertaining to weather, navigation, and takeoff/landing instructions, and
 - d. Observations and weather reports.

The report may be summarized by the following statements: (1) in a directed conversion to the metric system, the DOD transition will have a significant impact on mission capability unless sufficient additional resources are made available for the total task and a national conversion schedule is adhered to by industry; (2) the total additional funds for computed costs that will have to be made

available for transition to the metric system are estimated to be approximately \$18 billion; (3) during the period of transition there will be no major advantage to the DOD and major disadvantages will occur; (4) the conversion of the country to the metric system could adversely impact the ability of the United States to support its military forces during the proposed transition period; (5) the military advantages expected following transition are the day-to-day use of an inherently simpler system and the compatibility of U.S. and foreign equipment; and (6) should metrication be directed, a full-time and continuing staff within DOD will be required to prepare a detailed implementation plan, including contingency plans; and to implement and administer the metric system plan as appropriate.

The USMB research that discusses the Federal sector is presently underway. The Federal Procurement study (Ref. 36) is expected to be completed in the third quarter of fiscal year 1982. This study is designed to provide the USMB with a clearer understanding of the basic relationships between the Federal procurement process and private sector suppliers. This is being done to gain an understanding of the ways in which Federal procurement can encourage and accommodate initiatives of the private sector and to ensure that the effects of conversion on the Federal and private sectors are understood prior to implementation of procurement decisions and actions.

The study is being accomplished through the development and evaluation of classification schemes for products and services. These schemes will be based on the intrinsic characteristics of the products or services, as well as their effect and appropriateness of conversion considering both the Federal and private sectors. The intent of this study is not to examine each product or service that the Federal government procures. Rather, the ultimate goal of the study is to devise a meaningful and manageable classification scheme from which the appropriateness and methods for metric procurement can be derived.

Other USMB studies that related to the Federal and related constituencies are the distilled spirits conversion studies (Refs. 20, 29 and 30) which have been discussed at length in various sections in this report, and the gasoline pump conversion (Ref. 23).

A-14: International and Related Constituencies

The GAO report (Ref. 1) devoted parts of several sections to metrication and international trade in a chapter of their report entitled "Impact on U.S. Trade Uncertain."

The following conclusions, greatly condensed, were reached by the GAO: (1) companies in the forefront of metrication appear to be pursuing conversion for reasons other than a possible favorable impact on trade; (2) the frequently cited dollar losses in exports due to the United States not being on the metric system are often based on assumptions and estimates with questionable validity or reliability; and (3) the effect of metrication in promoting or deterring trade would appear to be relatively insignificant when compared to such factors as reliability, technology, quality, prices, and tariffs.

Two NBS U.S. Metric Study reports that relate to the International and Related Constituencies are the International Standards (Ref. 37) and International Trade (Ref. 36).

The conclusions and recommendations of the standards report reflected a substantial concern about the need to strengthen the effectiveness of the United States in international standards activities. The most important conclusions are summarized here: (1) the international standards issue lends some support to a metric conversion in the United States, but other important issues must also be considered and weighed before an overall judgment can be made; (2) if the U.S. wished to see the maximum amount of its engineering practices and standards included in the coming international standards, it must quickly participate effectively in international standards negotiations; (3) relatively modest changes in the import-export pattern of measurement-sensitive goods can have a serious impact on the U.S. balance of payments; (4) SI usage in international standards as a language does not of itself pose any serious complications for the U.S.; and (5) product certification emerges as a primary consideration in the utilization of standards.

The major recommendation of this report was that the Department of Commerce take appropriate action to determine whether the economic impact of agreements such as the Tripartite Agreement can be expected to affect the U.S. balance of payments significantly.

The major findings in NBS's International Trade report are briefly summarized as follows: (1) U.S. export trade volume in product classes judged to be measurement standard sensitive (MSS) amounted to \$13.9 billion in 1969, a gain of 47.1 percent over 1965; (2) Canada is the largest market for MSS products shipped by the U.S.; (3) the notion that the U.S. is losing exports to metric countries because its products are not designed and manufactured in metric units and standards appears to be ill-founded; and (4) most exports of MSS products involve machinery and equipment.

The USMB research studies relating to large corporations have discussed international and related constituencies. In the "Status of the Fortune 1000" study (Ref. 9) it was noted that the most frequently stated reason for conversion related to international acceptance. Other major conclusions of this study have been previously noted.

The Impact of Laws on Metric Conversion study's (Ref. 11) conclusion and recommendations have been referred to at length above. Those laws that do concern representatives of the Fortune 1000 (the most internationally oriented of the companies involved in metric conversion activities in the U.S.) were found to be evenly divided between the Federal and state/local levels of government. No major recommendations from this study related to the international or related constituencies.

In the consumer-related studies of the USMB the international and related constituency was not often noted either in study conclusions or recommendations. One exception to this observation is for Distilled Spirits Containers studies (Refs. 29 and 30) referred to throughout this report. Therein it was concluded that the implications of a conversion for international trade were not fully considered.

The study on the machine tool industry (Ref. 39) provides valuable information on the international trade implications. The study is described in more detail in the second perspective under the eighth mandate (Appendix B). The major finding relative to the international arena shows a serious decline of the U.S. share of the world market. This share has been somewhat masked by the fact that the dollar volume of overseas sales has increased. The U.S. now ranks sixth in the share of foreign sales. The world market is four times as large as the domestic market. The machine tool industry is beginning to look to the international arena with renewed interest since the large backlog of domestic orders has largely disappeared.

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APPENDIX B

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APPENDIX B

PERSPECTIVE NUMBER 2: FUNCTIONAL MANDATES OF THE METRIC CONVERSION ACT OF 1975

B-1: Approach

Each of the 11 mandates comprising Section 6 of the Act are considered in turn. All the research, research-related and allied source material has been reviewed to determine:

- (1) the extent to which the planned results of the research relate to the mandates, and
- (2) the extent to which serendipitous results relate to the mandates.

The process is not particularly elegant, nor can it guarantee that all relationships have been found. However, its very "brute force" nature provides reasonable assurance of completeness. The results of the review are presented by mandate. In analyzing each mandate, the review of USMB research studies are discussed under the appropriate topical headings.

B-2: Mandate 1: Consultation

The first mandate reads:

"the Board shall consult with and take into account the interests, views, and conversion costs of United States commerce and industry, including small business; science; engineering; labor; education; consumers; government agencies at the Federal, State and local level; nationally recognized standards developing and coordinating organizations; metric conversion planning and coordinating groups; and such other individuals or groups as are considered appropriate by the Board to the carrying out of the purposes of this Act. The Board shall take into account activities underway in the private and public sectors, so as not to duplicate unnecessarily such activities."

The relevant language of direct interest to research activities is that referring to the "interests, views, and conversion costs" of a wide range of groups and organizations. Surveys conducted to elicit views and studies looking at cost provide the most immediate source of information.

B-2a: Small Business Studies

(1) A probability survey of five types of businesses (Ref. 1) (representative of construction, manufacturing, retail and wholesale trade, and transportation) yields the following observations:

- There does not appear to be any significant amount of metric conversion planning underway.
- Trade or business associations are not seen as vehicles for metric conversion planning.
- For the majority of small businesses, the cost of converted products is generally the same as the cost of customary products.
- Small business feels that it should be represented in the conversion planning process.
- Lack of demand from customers and suppliers is the major reason for a lack of conversion planning.
- Demand from customers and suppliers, or conversion by the particular industry, are the primary reasons for conversion.
- Although problems were encountered by converting firms, the problems seem to have been overcome within the firms' own resources.
- If businesses were forced to metricate under extreme pressure, a strong need for government assistance is projected.
- Firms with no plans to convert envisage considerable difficulty in converting, associated with high costs; converted firms indicate problems and costs are minimal.
- The role and responsibilities of the USMB are not well understood.

(2) A cost-benefit analysis (Refs. 2 and 3), focussing on firms that have converted to identify significant costs and other problems of conversion, yields the following:

- Manufacturing firms generally convert only a portion of their production to meet specific customer demand; and much conversion takes place by converting metric specifications into customary units

for production and then re-converting for quality inspection and delivery.

- Conversion generally costs very little, both in absolute terms (less than \$10,000) and in relative terms (insubstantial, in the eyes of the converting firms' management). The investments can be described as routine, insubstantial and difficult to isolate from other business costs; the costs of metrication pale in comparison to concerns over inflation, interest rates, energy and material costs, and the general economic situation.
 - Large corporations often assist their small business suppliers in meeting the larger firms' demands. However, large businesses seeking metric products treat large and small businesses alike; that is, requests for metric products are matter-of-fact and not considered extraordinary. Metric fits comfortably into established relations among large manufacturers and small suppliers.
 - Conversion, as it occurs at present (gradually and at low cost), neither hurts nor benefits small business; working to metric presents no exceptional problems or benefits for small manufacturers.
 - There is little awareness of or interest in sector planning for conversion; conversion occurs on an individual company level and few companies know of others in their area or industry that have converted.
 - While often an important consideration, metric conversion is rarely a primary concern in a manufacturer's business decisions. The decision to convert, driven principally by customer demand, is neither voluntary nor forced.
 - The role and responsibilities of the USMB are not well understood.
- (3) A series of six case histories (Ref. 4), two of which concern small business firms, provide the following observations:
- A machine tool manufacturer sought foreign markets as a source of business for new growth; partial conversion to metric was to help reach the new customers; no problems with domestic customers occurred.

- Anticipated high costs of buying new taps, drills, reamers and fasteners, and re-tooling, led to a decision to postpone conversion of all equipment; also, management feared that skilled machinists, required to buy new personal tools, would choose to leave the company instead.
- The firm expressed the hope that the Federal government will take a more active role in conversion, to assure that similar small businesses are not placed at an economic disadvantage.
- A paint manufacturer was forced to return to customary-sized containers after converting because of difficulties with the supply of containers.
- The conversion to metric encountered few problems and no important customer resistance; nor was cost a significant factor. Re-conversion (to customary sizes) also did not face any important problems. Sales were not affected by either measurement system.

B-2b: Large Business Studies

- (1) A probability survey of the largest U.S. manufacturing and mining firms, designated as the Fortune 1000 (Ref. 5) yields the following:
 - The principal reasons for converting are meeting international standards (or because the metric system is internationally accepted) and meeting customer demand.
 - Limited conversion planning and coordination activity is evident, not only within individual firms, but also among industry groups. A very modest increase in the extent of internal (to the firm) planning and coordination activities over that observed by the General Accounting Office earlier (Ref. 6) is noted.
 - The prevailing disposition is a "wait and see" attitude; suppliers wait for customers to demand metric products while customers wait for suppliers to make the first move. Coordination between suppliers and customers, at both the individual and industry levels, appears limited.
 - Impediments (real or imaginary, legal and non-legal) hinder, if not discourage, some firms from converting, affecting both the pace and degree of metrication.

- The role and responsibilities of the USMB are not well understood.
- (2) Four of the previously cited six case studies (Ref. 4) deal with large business firms. Observations from the case reviews are:
- The reasons for conversion vary among the four large firms: (1) interest in international production, sales and services; (2) conversion in a Federally regulated industry, at the request of the industry, in an attempt to standardize product sizes and reduce the number of sizes in which the product is packaged; (3) demand for metric sizes of the raw material (steel) by large converted customers; and (4) a feeling that metric sizing (soft conversion) would be useful in a society (the U.S.) where metric use was on the increase (e.g., in schools).
 - No significant problems were encountered or extraordinary costs incurred by the conversions.
 - The planning process was entirely self-contained (within the firms) for three of the conversions, and industry-wide for the regulated firm.

B-2c: Worker Studies

- (1) An analysis of metrology sensitive occupations (Ref. 7) reveals that:
- Workers are not usually required to replace customary tools with metric tools all at one time; metric tools of equivalent quality cost about the same as customary tools.
 - Based on a probability sample, more than half of the occupations defined by the U.S. Department of Labor are not metrologically sensitive.
- (2) Purposive surveys of workers in metrology sensitive occupations (Refs. 8 and 9) provide the following:
- Most often employers pay for metric tools and training; for some specific occupations (e.g., automotive mechanics and senior tool and die makers), workers are expected to buy the necessary tools. Tools are generally purchased incrementally over a number of years.

- Anxiety with respect to metric conversion is experienced by workers, particularly elderly ones and workers scheduled for metric training.
 - There is confusion about U.S. policy regarding metric conversion.
 - Labor involvement in metric conversion is essential; collective bargaining processes are starting to address metric matters.
- (3) A purposive survey and review of occupational job tasks and duties was performed to assess the potential existence of occupational safety hazards when metric conversion occurs (Ref. 10). The study provides the following:
- No metric hazard experience was identified. In many instances, hypothetical scenarios were provided that characterized the potential for hazard, but none of these could be substantiated with actual experience.
 - An increased exposure might occur when particular jobs and their job tasks are going through the transition from customary measurement to metric measurement. Specific occurrences related to the tasks include: (1) worker judgment is exercised in using measurement; (2) communication of a measurement value between two workers; and (3) conditioned response in emergency situations involving measurement parameters.
 - Well planned metric change programs reduce hazard potential. Industrial safety programs can reduce metric hazards. Involvement of professional safety experts in metric planning, metric training programs, and procedural analyses can reduce the potential exposure to hazards resulting from metric change.
 - Metric safety issues are unresolved in the aviation industry. At the present time, the aviation industry is experiencing increased usage of metric measurement at the international level. Many potential safety issues related to aviation's adoption of metric measurement can be identified in U.S. periodicals, but these have not yet been resolved nor has a comprehensive aviation conversion plan been developed and endorsed by the industry.

B-2d: Consumers

- (1) An analysis of the gasoline retail dispenser computer conversion (Ref. 11) provides the following:
 - From a dollar cost standpoint only, conversion to the dispensing of gasoline by the liter is considerably less expensive than conversion of the systems to account for gasoline at prices greater than \$1 per gallon. However, consumer opinion of the conversion was not assessed and reaction to conversion is only sampled unsystematically.
 - There are no important legal barriers to the dispensing of fuel by the liter.
 - Information to allow price comparisons must be available at the pump.
- (2) An internal review of the USMB's own consumer activities (Ref. 12) indicates that:
 - The agency lacks a mechanism for servicing consumers in a consistent, focussed and coordinated manner. This is true in spite of the fact that considerable effort has been devoted to developing sound educational materials and to the establishment of practices and procedures which permit consumer participation in agency proceedings.
- (3) A probability survey of consumers, related to an evaluation of USMB procedures regarding conversion planning (Ref. 13), provided the following:
 - Consumers are generally aware of the conversion of the product used as the case for the evaluation (distilled spirits containers).
 - While consumers generally are not knowledgeable about the amount of contents (of distilled spirits) they buy, they are reasonably satisfied with the available sizes.
 - The most common means for learning about the conversion was from reading the size information on the container or the label.

B-2e: Legal Issues

- (1) An extensive review of legal barriers, deterrents and nuisances affecting conversion (Ref. 14) and a USMB report on the requirements for legislative corrective action (Ref. 15), yield the following observations:

- No legal barriers to the use of the metric system exist.
 - However, if the thousands of legal deterrents existing at all levels of governmental laws and regulations are left to be changed on an individual basis, a significant potential impediment to voluntary conversion exists.
 - Method of sales laws do not present legal barriers to the introduction of metric sizes.
- (2) An antitrust handbook, developed by the USMB (Ref. 16), provides guidelines for the participation of organizations in defining the interests and views of businesses considering metric conversion. Excluded from discussions among firms planning conversions are prices, costs, inventories, production data, marketing plans, and boycotts.
 - (3) An examination of the perceptions of some large industrial firms with respect to legal barriers to conversion (Ref. 17) indicates that:
 - Antitrust considerations still influence the way some businesses view cooperative sector planning for conversion.
 - The other principal legal area of concern to conversion is that of building codes.

B-2f: Policy Issues

- (1) An extensive study conducted by the Department of Commerce in response to a Congressional Act led to the most recent national consideration of the issues of metrication, and, ultimately, to the Metric Conversion Act of 1975. That study (Ref. 18) provides the following observations:
 - Within the broad framework of a national conversion program (recommended by the Commerce Department) and a Federal central coordinating body, industries, the educational system, and other societal segments should work out specific timetables and programs, dovetailing them with programs of other segments.
 - The Government would have a special responsibility to ensure that small businesses, including self-employed crafts workers are properly informed and their interests adequately represented.

- Some accommodations would be necessary to permit cost-saving coordination while avoiding illegal restraints on trade.
- (2) An equally extensive study by the General Accounting Office (Ref. 6), also in response to a Congressional request, essentially rebutted the observations and recommendations of the Commerce report. Among other findings, the GAO report stated that:
- The specific effect conversion would have on the U.S. economy is undeterminable (sic) but the impact on U.S. society would be great.
 - Actually achieving the benefits believed by many to accrue from metrication is questionable and the values of the benefits are generally undeterminable (sic).
 - The total cost of metrication is likewise undeterminable (sic), in spite of various estimates that have been cited. The estimates vary widely and often are not based on detailed analysis of the factors involved. They generally are low or high depending on the conversion experience of those providing the figures and their position on conversion.
 - Based on the limited cost data available and the input from representatives of a wide spectrum of organizations, the cost will be significant (in the billions of dollars).
- (3) An evaluation of the USMB policy and procedures with regard to metric planning (Ref. 19) yields the following:
- Regardless of the planned timetables and original motivation, actual implementation of metrication will be controlled by perceived market factors.
 - Regardless of the adequacy of the planning, the actual implementation will uncover problems which had not been foreseen. The plan should include provisions for resolving such unanticipated difficulties.
 - Industry, even when working with a regulatory agency, cannot be relied upon to explore the impact of the conversion on consumers very deeply or invest time and money on finding and implementing ways of minimizing the impact.

- Conversion is an activity which occurs within the context of the market place and private interests. It must, therefore, be expected that all evidence submitted, including economic and technological evidence, will support the market or private position of the originator. Hence, when the evidence appears to deprecate the interest of one or the other party in the conversion, it should be carefully examined for completeness.
- Some features of conversion may tend to favor the competitive position of certain participants over that of others. Within the restrictions of the antitrust laws, this is part of the market mechanism. However, in planning, there may be important impact areas to highlight, particularly for small business.
- The implications of a conversion for international trade are apt not to be fully considered. While the immediate trade position of participants, both as regards export opportunities and import competition, are likely to be fully analyzed, the opportunity of bargaining about related tariff and non-tariff matters is likely to be lost.
- While the planning for metrication is made at the highest corporate levels, the technical planning for implementation and the actual implementation are performed at the operating level.
- The actual costs and savings of the conversion are small fractions (less than one percent) of total costs or revenues.
- The USMB planning guidelines are essentially adequate to support the Board's options for safeguarding the interests of all participants and affected parties in conversion planning.
- In exercising its role, the most effective options for the USMB are those which elicit the positions of interested and affected parties and publicize the results.
- Much of the USMB's role is based on the concept of reviewing industry-provided documentation. It was found that such documentation is likely to be fragmentary and incomplete. This is due to the fact that:
 - much information will be company confidential; many contacts are informal, and not carefully recorded; and

- negotiations and "horsetrading" that occur are complex and illusive. Even if the final decisions are recorded, the key positions of participants may not be.

B-2g: Research Methods Studies

- (1) In the process of assessing methods of measuring the status of metrication (Ref. 20,) it was found that:
 - Metric use is so diverse in type and importance for industry, government and daily life that a single measure of use is impractical. A profile of metric use is more appropriate.
 - The temptation is as great as it is misleading to concentrate on the institutionally visible aspects of metric use (planning, conversion budgets, grants for training). Most important are business and industrial changes, new capabilities, marginal production changes, new supplier-customer relations-- which are relatively hidden from view.
 - The conversion of the industrial base paces the conversion of other institutions and daily life.

B-3: Mandate 2: Procedural Guidelines

The second mandate reads:

"the Board shall provide for appropriate procedures whereby various groups, under the auspices of the Board, may formulate, and recommend or suggest, to the Board specific programs for coordinating conversion in each industry and segment thereof and specific dimensions and configurations in the metric system and in other measurements for general use. Such programs, dimensions, and configurations shall be consistent with (A) the needs, interests, and capabilities of manufacturers (large and small), suppliers, labor, consumers, educators, and other interested groups, and (B) the national interest."

The language of direct relevance to the Board's research activities is that referring to "provide for appropriate procedures (so that) groups . . . may formulate . . . programs for coordinating conversion." Further, the identification of manufacturers, suppliers, labor, consumers, and educators, as groups of particular concern is also of relevance. There is close association between the first mandate (above) and mandate 2, and much discussion in the above Section holds here as well.

B-3a: Small Business Studies

Both the probability survey of small businesses (Ref. 1) and the cost benefit analysis (Refs. 2 and 3) found that small business does not participate in coordinative activities. Such is particularly true with regard to metrification planning, seen as a reactive rather than an initiative event. Small business feels that it should be represented in the conversion process and, therefore, be less likely to be required to respond to the needs of customers unwarned. However, in fact, small firms are generally unaware of metrification activities around them, both geographically and industrially.

B-3b: Large Business Studies

The survey of the Fortune 1000 firms (Ref. 5) found limited conversion planning and coordination both within the firms and across industries.

B-3c: Worker Studies

The studies of metrology sensitive occupations (Refs. 7, 8, 9, and 10) did not yield any indications of involvement of workers in the conversion process, although it was observed that labor involvement is essential and that the collective bargaining processes are starting to address metric matters (Ref. 9).

Board procedures provide for worker participation in the conversion planning process.

B-3d: Consumers

Although a formal process for serving consumers in a consistent, focussed and coordinated manner is lacking at the Board (Ref. 12), consumer participation of contemplated conversions is managed in two ways. First, by invited testimony at hearings. For example, during hearings related to gasoline retail dispenser computer conversion (Ref. 11), the Board invited representatives of major national interest groups. Accepting and providing testimony were: the U.S. Office of Consumer Affairs, the International Association of Machinists, the New York City Department of Consumer Affairs, the Conference of Consumer Organizations, the Suffolk County (NY) Department of Consumer Affairs, and the Consumer Association of Canada. Advertisements, announcing the hearings and soliciting comments from consumers, were placed in newspapers in major cities throughout the U.S. Travel funds were available to assist consumer representatives to attend the hearings.

The second way of introducing consumer involvement in the conversion process is through the Board's Private Sector Metric Conversion Planning Guidelines. The Guidelines suggest, in a number of places, the involvement of consumers (as well as labor and small business) in the planning process (initial working groups defining objectives and in conversion committees engaged in detailed planning).

A review and analysis of a major conversion (that of distilled spirits containers (Ref. 19)) observes that consumers, with the rare exception of a few individual speakers (at hearings) and writers (of comments for the record), did not participate in the conversion planning process -- nor were they specifically invited by the responsible Federal agency (the Bureau of Alcohol, Tobacco and Firearms, Department of the Treasury) or the industry's principal representative, the Distilled Spirits Council of the United States. The analysis concludes with the observation that industry cannot be relied upon to explore the impact of the conversion on consumers very deeply or invest time and money on finding and implementing ways of minimizing the impact.

B-3e: Legal Issues

All of the assessments and guidelines (Refs. 14-17) indicate that there are no legal barriers to conversion and that conversion planning, if carried out openly and with regard for restraint of trade matters, can be a cooperative effort. More emphatically, if all who can be affected by the conversion are included, fully and openly, in the planning, restraint of trade behavior is less likely to occur and be subject to antitrust actions.

B-3f: Policy Issues

The evaluation of the USMB policy and procedures (Ref. 19) suggests a series of steps or actions that would help provide the appropriate procedures for coordinating conversions:

- Conversion plans should include provisions for dealing with unanticipated consequences.
- When evidence is provided that deprecates the interests of other parties in the conversion, it should be carefully examined for completeness.
- One should be alert to features of conversion that tend to favor the competitive positions of certain participants over that of others. As long as restraint of

trade actions are absent, such advantages may be a function of market behavior. In planning, impact areas should be highlighted so that groups, such as small business, are not unduly affected.

- The most effective options for the USMB in participating in conversion planning, are those which elicit the positions of interested and affected parties and publicize the results.

B-4: Mandate 3: Public Hearings

The third mandate reads:

"the Board shall publicize, in an appropriate manner, proposed programs and provide an opportunity for interested groups or individuals to submit comments on such programs. At the request of interested parties, the Board, in its discretion, may hold hearings with regard to such programs. Such comments and hearings may be considered by the Board."

In holding the Hearings on retail dispensing of gasoline by the liter and subsequent report (Ref. 11), the analysis showed that a dollar cost savings of approximately \$90 million would accrue by dispensing by the liter. Research and costs studies were not performed by the Research staff for the hearings of the chemical and instrument sectors' plans.

B-5: Mandates 4, 5, and 6: Standards Conversion, Retention, and Consultation

The fourth, fifth and sixth mandates, all relating to standards, are discussed together. The fourth mandate reads:

"the Board shall encourage activities of standardization organizations to develop or revise, as rapidly as practicable, engineering standards on a metric measurement basis, and to take advantage of opportunities to promote (A) rationalization or simplification of relationships, (B) improvements of design, (C) reduction of size variations, (D) increases in economy, and (E) where feasible, the efficient use of energy and the conservation of natural resources."

The fifth mandate reads:

"the Board shall encourage the retention, in new metric language standards, of those United States engineering designs, practices, and conventions that

are internationally accepted or that embody superior technology."

The sixth mandate reads:

"the Board shall consult and cooperate with foreign governments, and inter-governmental organizations, in collaboration with the Department of State, and, through appropriate member bodies, with private international organizations, which are or become concerned with the encouragement and coordination of increased use of metric measurement units or engineering standards based on such units, or both. Such consultation shall include efforts, where appropriate, to gain international recognition for metric standards proposed by the United States, and, during the United States conversion, to encourage retention of equivalent customary units, usually by way of dual dimensions, in international standards or recommendations."

While research efforts have not specifically focussed on standards matters as a major consideration, a number of studies have dealt with standard-related matters.

B-5a: Small Business Studies

- (1) In the probability survey of small businesses (Ref. 1), firms not now designing, manufacturing or providing a product or service in metric measurements were asked for reasons for their non-involvement in metrics. Slightly less than 20 percent said that the changing of codes and standards was a reason for not undertaking metric action.
- (2) The GAO analysis of modularization of shipping containers (Ref. 21) emphasizes the desirability, resulting efficiencies, and reduced costs attendant to conversion of the myriad food shipping container sizes to a geometrically related set. While metric dimensions are not necessary for such a conversion, the GAO charged the USMB with consideration of modularization in any metrication actions to change package sizes in the food industry. No such actions have been proposed for the Board to consider.
- (3) The cost-benefit analysis (Refs. 2 and 3) identifies as a plaguing matter the failure of the domestic automobile manufacturing industry to agree on metric standards for fasteners and fastener-related items (e.g., washers).

- (4) In one of the small business case studies, from the set of six (Ref. 4), the matter of standards is of concern. The paint manufacturer who returned to customary sizes for the product, did so because the industry was unwilling to accept metric sized containers as standard for general use in the paint industry.

B-5b: Large Business Studies

- (1) The probability survey of the Fortune 1000 firms (Ref. 5) included a query regarding standards; the firms were asked to state the extent to which they develop metric design and engineering standards. Of companies working in metric measurement to some extent, slightly less than half indicated that they were doing nothing in the standards area. Slightly more than half indicated they either had plans to design to metric standards or were into such designs.
- (2) Two of the four large business case studies (Ref. 4) deal with standards. In one situation (a major farm machinery manufacturer), metric standards for fasteners have not been introduced (even though the firm's products are converted) to avoid carrying a dual inventory in fasteners; the product line's longevity is of the order of 50 years. The firm feels that the current lack of acceptance of uniform worldwide metric standards for fasteners eliminates the usual argument for standardization, and that good availability of customary sizes of screws, nuts and bolts exists throughout the world, partly because they are produced around the world for sale in the United States.

The second case concerns alcoholic beverage containers which is discussed more completely below (Section B-5e.(3)).

B- : Consumers

The results of the distilled spirits container study (Ref. 19) indicate that the standardization did not particularly benefit consumers, but the negative effect was moderate and incidental to the conversion.

B-5d: Legal Issues

- (1) The review of laws (Ref. 14) and the Board's report on the requirements for mechanisms to eliminate legal barriers to conversion (Ref. 15) indicate that the designation of standards in laws, regulations and ordinances in customary terms represents a deterrent

(making it costly, cumbersome or difficult) to the use of metric terms and sizes. Setting aside the number of times units of measure are cited in laws, regulations and ordinances in general and legal descriptive ways, standards citations represent about 14 percent of the remaining deterrents. The implication of this observation is that to remove the deterrent, considerable administrative effort would have to be expended.

- (2) The antitrust guidelines (Ref. 16) discuss the matter of standards at length. With respect to cooperative metric conversion planning, the risk of antitrust liability (i.e., unnecessarily placing some firms at a competitive disadvantage, raising barriers to entry, or stifling product improvement or innovation) is not inherently greater than the risk associated with normal standardization activity. Antitrust violations associated with standardization activities have been found only when the challenged activity has been, or has closely resembled, a per se violation (e.g., price fixing or group boycotts). Guidelines (metrication "do's and don't's") are established in the standards making context:

- Any industry meetings to discuss conversion (or standards) should be well publicized and open to any person.
- A written agenda of issues to be discussed should be published or circulated to interested parties in advance of meetings.
- Complete and accurate records of meetings and all activities should be maintained.
- Written procedures for metrication planning could be useful; in the case of standards development they may be required.
- Prior to any formal decision to adopt target dates, standard metric sizes, etc., members of the industry should be given written notice of the proposal.
- Any information developed relating to metric conversion should be made available to suppliers, purchasers, and the general public at the same time it is made available to industry members.
- Target dates should be reasonable.
- Conversion plans and target dates should be voluntary.

- Persons and companies should have an opportunity to air complaints.
- Discussion of prices should be avoided.
- Discussion of specific costs should be avoided.
- Discussion of existing or anticipated inventory size should be avoided.
- Future production plans should not be discussed.
- Discussions favoring or urging boycotts should not take place.
- Establishing product standardization and rational sizes should be approached with care.
- Active involvement with the U.S. Metric Board is encouraged.
- Consultation with antitrust counsel should be the watchword if any issues are raised that could be seen as in restraint of trade.

B-5e: Policy Issues

(1) The Bureau of Standards' study (Ref. 18) resulted in two supporting reports dealing directly with standards matters: International Standards (Ref. 22) and Engineering Standards (Ref. 23). Relevant conclusions of the International Standards report are:

- The international standards issue lends support to a U.S. metric conversion, but other important issues must also be considered before an overall judgment can be made.
- If the U.S. wants to see the maximum amount of its engineering practices and standards included in international standards, it must, without delay, take steps for effective participation in international standards negotiations.
- If the U.S. increases and makes more effective its participation in international standards making activities, the degree of incompatibility between U.S. domestic standards and international recommendations would be reduced, and a U.S. metrication program would be facilitated, if one were undertaken.

- Relatively modest changes in the import-export pattern of measurement sensitive goods can have a serious impact on the U.S. balance of payments. Hence, the relation between standards, standards use and trade should be carefully studied to develop the policy base for U.S. participation in international standards development and use.
- SI use in international standards as a language does not of itself pose any serious problems to the U.S.
- Product certification emerges as a primary consideration in the use of standards.
- Some product certification schemes for exports will probably be required to maintain a competitive position if European plans are successful. The plans can be either compatible with those now developing in Europe or distinctively U.S. approaches, conceived to provide assurance that U.S. export products meet a set of explicitly stated standards.
- If the U.S. elects to certify products in terms of IEC-ISO (International Electro Technical Commission - International Organization for Standards) standards, it must recognize that the critical decade of standards development is here and take the necessary steps for participation. (The report was written about 1970).

The Engineering Standards (Ref. 23) study resulted in 21 conclusions, many of which are not relevant to the present concerns. The recommendations more succinctly imply the key findings and are therefore used here:

- The highest priority should be given to reviewing and revising engineering standards in any metrication program, whether evolutionary, planned or mandatory.
- International standardization should be fostered to achieve the greatest economic benefit (see above).
- Any metrication program should be used to effect a reduction in the number of product sizes, conservation of materials, and product quality improvement, through international standardization.
- The use of SI units, alone or with customary units, in U.S. standards should be promoted to foster the international acceptance of the U.S. standards; the

standards should be drafted in such a form as to permit easy use in metric countries.

- Standardization of new practices and technologies, requiring standardization beyond the company level, should begin at the international level to avoid the high cost of international standardization after national practices are established.
- Except for the inclusion of SI units, no change in domestic standards should be made when the cost of the change is very large compared to the benefits (e.g., the standard for railway gage of existing railroads).
- Special attention should be given to the administrative process of standardization to assure adequate U.S. participation in international standards groups, and to the development and issuance of national standards required by the consumer, industry and government.

(2) The GAO study (Ref. 6) also examined the standards issue and concluded that:

- Metrication of U.S. engineering standards is not necessary to increase standardization, rationalize existing standards, remove outmoded standards, revise standards, or improve technology. These could be done under the customary system. Metrication could cause standards writers and industry to take a penetrating look at standards. Other events could also cause this to occur. (The GAO did not suggest what the other events might be. For an alternative view of the role of metrication in the standards activity, see B-5e(3), below.
- The overall cost to convert or develop metric standards has not been specifically estimated but is believed to be significant by those involved in standards development--several billions of dollars. The data supporting this observation are vague.

However, as seen in previous discussions of Board research, business has stated that most new products that have been designed and manufactured to metric dimensions costs about the same as a new customary product (Refs. 1, 2, 3 and 5). The Board's two surveys of standards writing organizations (Refs. 24 and 25) found the costs of developing or revising standards to be about the same as an inch-pound standard. Therefore it should be

remembered that the "several billions of dollars" estimate for metric standards development or conversion is predominantly the costs of developing new metric standards where no inch-pound standards existed before and should not be considered as a cost of converting existing standards to reflect metric measurements or thresholds.

- The GAO pointed out that conversion of standards could take place during the periodic review or update of standards, an event that occurs every three to five years. If such reviews are normal practice at a somewhat lower cost than that of development of standards then the cost of conversion carried out during the review time should be less than suggested by the GAO. Also, the GAO indicated that development of international standards would take twice as long as the development of domestic standards, by assuming that introduction of candidates for international standardization would occur only after acceptance as domestic standards. Such an assumption is contrary to the suggestion of the NBS (see (1), above), which was that standardization of new practices and technologies beyond the company level should begin at the international level to avoid the high cost of waiting until after national practices were established. On the other hand, expediting may not be possible if domestic standards organizations need to "sign-off" before a standard can become a candidate for international standardization.

(3) The policy and planning study, using conversion of distilled spirits containers as a case example (Ref. 19), observed an opposing point of view from that of the GAO (Ref. 6):

- Metrication was a necessary as opposed to merely a convenient mechanism to increase standardization. It was not possible to standardize sizes significantly without addressing the metric question, since BATF refused to require imports to convert to U.S. measure and such a large share of the market (about 15 percent) was taken by imported bottled spirits.
- The distilled spirits industry publicly stated reasons for the conversion were: cost savings from increased standardization, elimination of the competitive advantage and potential consumer deception posed by undersized imported products, and the promotion of international trade. (Two other objec-

tives, not publicly stated, were to restructure prices and eliminate unprofitable sizes.)

- BATF supported metrication because of: the possibilities for inter-industry (the wine and distilled spirits industries) standardization with potentially large cost savings; other cost savings to be passed on to consumers; and the resulting requirement that imported liqueurs and specialty items comply with U.S. standards of fill without a requirement to convert to U.S. measure.
- The conversion failed to use its potential in negotiations with European nations, particularly to effect concessions on product standards, labelling requirements, or reductions in high import duties on U.S. distilled spirits products.
- Many suppliers took advantage of the changes to standardize aspects of their packaging, resulting in substantial recurring savings. Bottles, labels and caps were often standardized and bottles reconfigured to use less glass.

(4) The Board surveyed over 400 standards writing organizations to assess metrication activities (Ref. 24). The mail survey achieved a response rate of 67 percent (283 out of 420 organizations). The major findings were as follows:

- 21 percent have a formal policy on metrication. Most of the policies support the Metric Conversion Act and voluntary metrication. Metric trends will be monitored. Also the policies state how metric units will be used in the organizations' standards and publications.
- 11 percent of the organizations have publications devoted to metrication.
- About 42 percent of the organizations primarily use English units in their technical publications, 5 percent use metric, and 38 percent use dual units (several more report other combinations).
- About 41 percent of the organizations use English units primarily in their standards, 6 percent use metric, and 31 percent use dual (again, several more report other combinations).
- When asked how many years will elapse before the constituencies they serve will be converted to

metric, 4 percent said they are now converted, 28 percent estimate 10 years, 16 percent estimate 25 years, 3 percent estimate 50 years and 20 percent estimate other periods (a few years) or state that it depends on their constituencies.

- (5) As a follow-up to the mail survey of standards organizations (Ref. 24), the Board performed indepth personal interviews with selected standards writing organizations (Ref. 25). The study was conducted with nine major standards organizations that have historically developed a predominant proportion of U.S. voluntary consensus standards. The major findings of the study were as follows:

- Metrication is neither a major issue nor problem for standards developing organizations.
- Several barriers to the development and use of metric standards exist and have been cited by standards developers. At present, the greatest barrier is simply the lack of demand for such standards. A significant barrier to metrication is competitively priced items or systems, whether in government or industry. Costs of metric standards may be higher than for inch-pound standards when first developed. Safety problems were cited as barriers. Present use of inch-pound standards by regulatory agencies has not served as a significant barrier to the development and use of "metric" versions of standards.
- Standards development organizations react to market demand for their standards. Although the Department of Defense has announced a target date of 1990 for having necessary military metric standards available, there is at present no clearly articulated pressing demand for metric standards from industry, government agencies, or other users of standards.
- Standards developing organizations acknowledge the need for raising awareness among both the standards users and standards writing organizations of the advantage of continuous attention to consideration of hard metric in new product design, and especially in new technology areas.
- While standards work generally follows technology, it is feasible to manage metric standards development to support planned product conversion to metric. Since there is little perceived market for

metric dimensioned products, there is little support in industry or government for such anticipatory conversion of standards to metric.

- For Federal agencies to have a real impact on the pace of metric standards development, agencies would have to specify metric in procurement.
 - Some organizations are concerned about the threat of foreign origin standards displacing U.S. non-metric standards but most standards writing organizations do not view this as a major problem. The standards bodies cited no cases where "foreign origin" international standards have replaced U.S. originated defacto or recognized international standards because these U.S. standards are not metric. Other factors, such as different power system voltage and frequency requirements, are far more important considerations for international acceptance of U.S. standards than whether or not a standard is in metric units.
 - All of the interviewed standards organizations indicated that as yet, the fact that U.S. standards are not metric, has not been a deterrent to international acceptance of U.S. inch-pound standards.
 - Standards developers generally felt that they have the infrastructure in place to respond to a significant increase in demand for the development of metric standards should such a demand develop.
 - Because of the wide variety of industry economic factors and technology, a single strategy for encouragement of anticipatory conversion of standards is difficult to develop.
 - There is mixed feelings about the value of a national metric "log" or status report on conversion of standards. There is a feeling that if metrification is merely drifting along as it is now, such a log would not be of much value except in the aerospace area. However, in the event of a national conversion or an industry-wide decision to go metric, a metric log would be useful.
- (6) The status assessment of the U.S. machine tool industry (Ref. 26) observed the following:
- One of the forces retarding the introduction of metric designed and capable tools was the lack of metric standards.

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- Limited domestic demand for machine tools retarded the introduction of metric products.
- As seen in the surveys of the standards writing organizations (Refs. 24 and 25), an apparent lack of demand of metric standards has been a major problem. This apparent dichotomy is explained by the vertical and horizontal spread of the American economy. Standards writing organizations respond to their customers' demand. While a particular industry or segment of an industry may desire a metric standard, the demand for standards development is not sufficient for the standards writing organization to undertake the development. The standards arena is similar to the marketplace, i.e., when there is enough demand to make it "profitable" or "my customers want it" then metric products are produced.

B-6: Mandate 7: Public Information and Education

The seventh mandate reads:

"the Board shall assist the public through information and education programs, to become familiar with the meaning and applicability of metric terms and measures in daily life. Such programs shall include --

- (A) public information programs conducted by the Board, through the use of newspapers, magazines, radio, television, and other media, and through talks before appropriate citizens' groups, and trade and public organizations;
- (B) counseling and consultation by the Secretary of Health, Education, and Welfare; the Secretary of Labor; the Administrator of the Small Business Administration; and the Director of the National Science Foundation, with educational associations, State and local educational agencies, labor education committees, apprentice training committees, and other interested groups, in order to assure (i) that the metric system of measurement is included in the curriculum of the Nation's educational institutions, and (ii) that teachers and other appropriate personnel are properly trained to teach the metric system of measurement;
- (C) consultation by the Secretary of Commerce with the National Conference of Weights and Measures in order to assure that State and local weights

and measures officials are (i) appropriately involved in metric conversion activities and (ii) assisted in their efforts to bring about timely amendments to weights and measures laws; and

- (D) such other public information activities, by any Federal agency in support of this Act, as relate to the mission of such agency."

While considerable effort on the part of the Board has been devoted to this mandate, no specific research or research related activities have been carried out relative to it. However, all surveys and reviews (studies of small businesses, large businesses, consumers, workers, and legal and policy issues; see Refs. 1, 2, 5, 8, 9, 10, 11, 13, 14, 15, 17 and 19 particularly) have identified the same phenomenon:

- the national policy on metrication, the significance and meaning of the Metric Conversion Act of 1975, and the USMB's role are, to varying degrees and with variable import, either misunderstood or not well understood.
- The studies of workers, tool and training issues (Refs. 8 and 9) showed training is usually provided by the employer with costs ranging from \$30 to \$150 per person. However, it was found that there is duplication of effort in developing training by individual firms, technical schools, educators and trade associations. As a results of this study, a feasibility study was to be initiated to determine the appropriateness of establishing a centralized metric industrial training and safety awareness materials clearinghouse. However, due to severe budgetary cutbacks, this project was not undertaken.
- The metrology sensitive occupations study (Ref. 7) showed while approximately 55 percent of the workforce was not sensitive to measurement change, 45 percent was. This implies metric training will be required to some degree to those affected occupations. It does not, however, imply that the other 55 percent will not require at least familiarization of the basic metric measurement units.
- The work place safety study (Ref. 10) found that industrial safety programs involving professional safety experts in metric planning, metric training

and procedural analyses can reduce the potential exposure of the workforce to hazards when metric change takes place.

B-7: Mandate 8: Status Assessment

The eighth mandate reads:

"the Board shall collect, analyze, and publish information about the extent of usage of metric measurements; evaluate the costs and benefits of metric usage; and make efforts to minimize any adverse effects resulting from increasing metric usage."

While no specific research or research-related activities have been devoted to the third clause of this mandate (minimizing adverse affects of metrication), all research findings and results have been considered and integrated into the planning and coordination efforts of the Board. These efforts are detailed elsewhere; see the Board's final report to the Congress and the President.

The first and second clauses (collect, analyze and publish information about the extent of use of metric measurements, and evaluate costs and benefits of metrication) are responded to in the research program by the surveys and reviews of industries.

B-7a: Small Business Studies

- About one-quarter of small business (as represented by manufacturing, construction, transportation, wholesale trade, and retail trade firms) are using metric measurement in some of their activities (Ref. 1).
- Metric activity is greatest in the machine and fabricated metal products industries (industries making products for other industries). Metric units have made fewer inroads to the highly diffuse consumer industries, such as food, apparel, leather goods, and furniture (Ref. 2).
- The capability of small manufacturers to produce metric goods is widespread; the depth of the capability depends directly on the extent of customer demand for metric products (Ref. 3).
- Small manufacturers are flexible; they use a rich repertoire of management and manufacturing practices to produce metric products (Ref. 3).

- Small manufacturers usually produce metric products for several large customers (Ref. 3).
- Manufacturing firms see metric products and services as being more expensive than customary sized goods, while retail and wholesale trade firms see the costs as essentially the same (Ref. 1).
- The actual costs of conversion among small businesses are routine, insubstantial and difficult to isolate from other business costs (Ref. 2 and 3).
- Small businesses only convert part of their production to metric because of customer demand. Usually, the customer is a large firm that has converted (Ref. 2).
- The decision to convert is neither voluntary nor forced; small businesses have not particularly benefited from metrication, nor have they been particularly hurt (Ref. 3).

B-7b: Large Business Studies

- About one-third of the sales of the nation's largest firms are of metric (hard, soft, and hybrid) products (Ref. 5).
- About half the export sales of the largest U.S. firms are of metric products (Ref. 5).
- About 60 percent of the largest U.S. firms produce at least one metric product (Ref. 5).
- Detailed cost data are very difficult to obtain from the large firms; they are unwilling to share cost experience information (Refs. 2, 3, and 5).

B-7c: Workers

- About half of the occupations defined by the U.S. Department of Labor are sensitive to measurement; correspondingly, about half are not (Ref. 7).
- Workers in particular converted or converting industries (e.g., automobile repair and maintenance) who typically buy their own tools have generally purchased the required metric tools and have not taken advantage of the tax deduction allowed (Ref. 9).
- Some workers experience anxiety when faced with conversion in the work place (elderly and others

scheduled for training, for example). After training, anxiety decreases; in some cases workers become highly enthused about the new skills (Ref. 9).

- No metric hazard experience was identified. In many instances, hypothetical scenarios were provided that characterized the potential for hazard, but none of these could be substantiated with actual experiences (Ref. 10).
- An increased exposure might occur when particular jobs and their job tasks are going through the transition from customary measurement to metric measurement. Specific occurrences related to tasks include: (1) worker judgment is exercised in using measurement; (2) communication of a measurement value between two workers; and (3) conditioned response in emergency situations involving measurement parameters (Ref. 10).
- Well planned metric change programs reduce hazard potential. Industrial safety programs can reduce metric hazards. Involvement of professional safety experts in metric planning, metric training programs, and procedural analyses can reduce the potential exposure to hazards resulting from metric change (Ref. 10).
- Metric safety issues are unresolved in the aviation industry (Ref. 10).

B-7d: Consumers

- No cohesive and responsive assessment of consumers' abilities to cope with conversion of retail gasoline dispenser computer has been undertaken, because of the use of research resources on other matters and problems (Ref. 11).

B-7e: Legal Issues

- Comprehensive analyses demonstrate that no serious legal barriers prevent metrification (Refs. 15 and 17). However, perceptions of legal barriers persist, particularly among the largest of the U.S. firms who have not started to convert (Ref. 5 and 14).
- Antitrust matters also concern large firms (Ref. 17) in spite of clarification of restraint of trade behavior in metrification and standardization planning (Ref. 16).

B-7f: Policy Issues

The GAO study (Ref. 6) gathered experience and opinion information from surveys of a wide variety of sources. Specific status and cost data are not easily summarized. Generally speaking:

- Large businesses are divided on whether advantages of metrication outweigh the disadvantages for their firms.
- Both small and large firms believe advantages of metrication outweigh disadvantages for the nation as a whole.
- The total cost of metrication is undeterminable, in spite of various estimates cited. The estimates vary widely and often are not based on detailed analyses. They are high or low depending on the conversion experiences and metrication positions of those making the estimates. However, based on the limited data available to the GAO and other input, the cost is judged by the GAO to be significant--in the billions of dollars.

B-7g: Broad Industrial Picture

A review of industry groups, carried out by Department of Commerce analysts, under an interagency agreement with the USMB (Ref. 27), provides the following summary. Analysis of industries were done at varying levels, using the Standard Industrial Classification codes, ranging from major groups (given two-digit identifiers), to industry groups (identified by three digits), to specific industries (four digits).

(1) Industries essentially fully converted:

- Radio and TV receiving equipment (hard conversion).
- Communication equipment (soft conversion).

(2) Industries partially converted, both hard and soft, and to widely varying degrees: Food and kindred products, Textile mill products, Furniture and fixtures, Pulp mills, Paper mills (except building paper), Miscellaneous converted paper products, Paperboard containers and boxes, Building paper and board mills, Book publishing, Blank books and book binding, Chemicals and allied products, Glass containers, Iron and steel foundries, Cutlery, hand tools and hardware, Bolts, nuts, rivets and washers,

Farm and garden machinery, Construction and related machinery, Metalworking machinery, Special industry machinery, General industrial machinery, Office and computing machinery, Refrigeration and heating equipment, Household appliances, Electronic components and accessories, X-ray apparatus and tubes, Tires and inner tubes, Transportation equipment, Engineering and scientific instruments, Optical instruments and lenses, Medical instruments and supplies, Ophthalmic goods, Photographic equipment and supplies, and Watches, clocks and watch cases.

- (3) Industries planning for conversion: General building contractors, Heavy construction contractors, Special trade contractors, Lumber and wood products, Paper-board mills, Cement, Hydraulic, Structural clay products, Gypsum products, Fabricated structural metal products, Valves and pipe fittings, and Turbines and turbine generator sets.
- (4) Industries in which no metric headway is seen: Metal mining, Bituminous coal and lignite mining, Apparel and other textile products, Newspapers, Periodicals, Book printing, Miscellaneous publishing, Commercial printing, Manifold business forms, Greeting card publishing, Printing trade services, Asphalt felts and coatings, Leather and leather products, Vitreous plumbing fixtures, Concrete block and brick, Concrete products not elsewhere classified, Mineral wool, Metal cans, and Plumbing and heating except electrical.

B-7h: Comprehensive Look at the U.S. Machine Tool Industry

The Metric Use in the Machine Tool Industry--A Status Report and Test of Assessment Methodology study (Ref. 24) served a dual purpose of testing the most promising methods of assessing metric status in the United States while providing an assessment of the current status and progress of the metrification activities of the machine tool industry. The machine tool industry provides capital equipment for other manufacturing industries including the automotive, aerospace, construction, and farm machinery industry. It is a small but critical segment of the national economy.

There have been a number of studies of industrial metrification, but they dealt with broad categories of industry and provided little detailed information about specific industries or about the process. This study drew directly on the experience of industry companies and on data from many public and private sources. It emphasized the present and potential interactions of metrification with other issues and problems facing the machine tool industry.

The major findings of the study have been grouped under two headings due to its dual purpose. The headings are Status and Methodology Assessment.

- Status

- Companies need better information on the status of metrication within their industry, the status of metrication in supplier and customer industries, and the implications of the status for the industry's competitiveness in domestic and world markets. At present, corporate decisions about metrication are made in the face of considerable uncertainty and lack of information.
- The lack of explicit Federal policy regarding metrication is a source of confusion and dissatisfaction for procurement activities, especially procurement policy of the Department of Defense.
- Metrication is progressing slowly but steadily. The machine tool industry is strongly oriented toward meeting customer-defined needs. Its major customers are pulling the machine tool industry gradually into metrication.
- Other important factors are the desire of multinational corporations to have U.S.-produced machine compatibility in their overseas subsidiaries, and the recognition that the U.S. share of the overseas market is eroding. Imports, especially Japanese imports, are also making inroads on domestic markets.
- Metrication is not a primary factor in the growing problems of the machine tool industry, but actions calculated to deal with these problems are likely to provide an impetus toward further metrication.
- Overseas demand and the small domestic demand for metric tools are met by building metric-capable machines. About ten percent of total sales now involve metric-capable products. The demand is perceived to be growing, but to be growing very slowly.
- The spread of new technologies may speed up conversion to metric use. New manufacturing technologies do not necessarily entail an accelerated transition to use of the metric system. But adoption of these technologies may be accompanied

by a simultaneous adoption of the metric system in new product lines.

- The major inhibiting factors are the large stock of machine tools already on hand, the long life-time of these tools, which are generally major capital investments, and the very large customer demand for machine tools built to customary units.
- The U.S. machine tool industry has a declining share of the overseas market, which is four times the size of the domestic market. The decline in overseas market share has been partially masked by the fact that the dollar value of machine tool exports has continued to rise.
- The general effect of a stronger world market orientation would likely be to spur metrication. Several large U.S. manufacturers have recently introduced metric-capable product lines aimed at the world market and one major company has introduced a hard metric product line.
- Machine tool manufacturers do not see conversion to metric use as a highly important issue. It does not promise to solve their problems, but much of the early fear of and resistance to metrication has faded.

- Methodology Assessment

- Because of the paucity of metric status data and the lack of clearly defined definitions of the elements for determining metrication status, the use of econometric modeling or aggregation of massive statistical data bases is not feasible at the present time.
- Surveys using in-depth discussions with practitioners in the business place, supplemented by qualitative descriptive analysis of the behavior of representative companies, are an appropriate and relatively low cost approach to status assessment. Such studies can produce information of practical value to the industry and to public sector decision-makers.

B-7i: Assessment of Selected Econometric Models

The objective of the survey of econometric models and data bases (Ref. 28) was to assess the applicability of existing econometric models for investigating impacts and implica-

tions of metrication in the United States. A parallel objective was to identify data bases which could facilitate the use of attractive econometric models, or be used in other productive ways. Econometric models and data bases at various levels of economic activity--the firm, sector, inter-industry, and aggregate level--were of interest.

The study's findings were as follows:

- Most government agencies that use econometric models and data base services use Data Resources, Inc., Wharton Econometric Forecasting Associates and Chase Interindustry Forecasting Model.
- No macroeconometric models in the Federal establishment were identified which the USMB could readily utilize at present.
- At present, there appears to be no realistic way to analyze large economic issues of metrication using econometric models because of the insufficient and inadequate body of economic knowledge and data bases concerning metrication issues.
- USMB need not subscribe to a host of forecasting services. Single-purpose studies would be a more cost-effective approach to conducting research, at least for an initial period and until more is learned through sector-specific analyses.

B-7j: Other Surveys

A large number of surveys have been conducted over recent years by business and trade associations, industrial magazines, university faculties, and private firms. Often, they do not qualify as properly designed and implemented probability surveys, so extension of the survey findings to the populations sampled is suspect. On occasion, the instruments are biased, also leading to questionable extrapolations. A number of surveys that have been reviewed and partially used by the USMB are listed, for completeness.

- (a) Holo-Krome Company surveyed a probability sample of 1000 subscribers to Purchasing Magazine in January 1981. About 29 percent (288) responded. The focus of the survey was on the fastener market. About 42 percent of the firms were producing metric products. Respondents predicted that in less than two years about 20 percent of all fastener production will be in metric units.

- (b) The National Tooling and Machining Association surveyed its members attending its annual conference in Freeport, the Bahamas, January 1981; the results were published in May 1981. The number attending was not provided; 101 companies responded. About 90 percent were performing some work to metric specifications; the firms were primarily in the automotive, electrical, electronic, and aerospace fields.
- (c) The Council of Engineering and Scientific Society Executives surveyed its membership in January 1980. The sample process was not specified. Sixty-six percent (89 of 134 surveyed) responded. About half the associations represented have a formal policy on the use of metric measures.
- (d) Three faculty members of the University of Tennessee at Chattanooga surveyed a probability sample of 750 members of the Fortune 1000 firms. About 38 percent (285) responded. The responses were categorized, after receipt, by company sales volume and type of industry. The results were published in the Advanced Management Journal, Vol. 45, No. 2 (Spring 1980); the date of the survey is not cited. The results are similar to those from the USMB survey of Fortune 1000 firms, (Ref. 5), carried out in 1979.
- (e) Pressure magazine, the quarterly of the Fluid Power Society, invited comments from about 200 company executive (subscribers said to be picked at random, but with wide geographic and product ranges). The comments were to cover metric plans and philosophies. Eight executives responded; their comments were published in the December 1980 issue.
- (f) The American Supply and Machinery Manufacturers' Association surveyed its membership in October 1979; results were published in Assembly Engineering magazine, September 1980. There were 361 responses, said to be about two-thirds of the membership. The maximum number of usable responses (for any particular question) was 320 (or about 60 percent of the membership, by extrapolation).
- (g) The Smaller Business Association of New England surveyed its approximately 1600 members in the spring of 1979. Less than 10 percent (about 150) responded. The questions referred to awareness

of national metric policy, problems with metric conversion, and possible benefits of metrication.

- (h) The Millers' National Federation carried out a survey in 1980 with regard to metric packaging for milled products (e.g., flour). One hundred seventy questionnaires were sent out; 77 responses (about 45 percent) were received.
- (i) In 1970, a NASA staff agency reviewed over 13,000 NASA reports produced between 1966 and 1969. About 22 percent contained metric units only, 32 percent contained engineering units (possibly customary), 30 percent contained both, and 16 percent contained no measurement units. In comparison with a previous review of publications of 1962 through 1965, there was a growth in the use of metric measurements (alone and combined) from 33 percent to 53 percent.
- (j) The Electronic Industries Association Metric Study Panel conducted a survey, undated but presumably in the fall of 1980 (the results were published in December 1980). The focus was on standards, status and problems. No indication is given of population or sample sizes; there were 52 responses.
- (k) The National Federation of Independent Businesses (NFIB), through its publication Mandate, a newsletter produced every six weeks, surveys its over 600,000 members on a variety of topics. The questions (usually five disassociated ones in each issue) are presented with pro and con arguments. Regularly, responses range from 10 to 30 percent of the recipients. In January 1979, the Mandate asked if the membership favored or opposed a national policy on conversion to the metric system. The responses totaled 55,401 (about 10 percent of the membership at that time). About a quarter were in favor, about 70 percent opposed, and the balance were undecided. An earlier (1973) similar survey yielded the following: about 50 percent for, about 40 percent opposed, and the balance undecided.

A final observation is that when executives are questioned about problems facing business now and expected in the future, the metric issue is conspicuous by its absence. Foreign competition is cited by a few, but alternatives, such as conversion for competition's sake, are not sur-

faced. Broad surveys such as that by the Chemical Bank of New York, looking at small and medium-sized firms in the New York area, and the NFIB quarterly economic survey (which asks for the most important problem facing each respondent and which includes an open-ended opportunity for answer) are typical. In other words, the metric issue is not a burning one, except when attention is directly focussed on it--and then only among a small portion of society.

B-8: Mandate 9: Research

The ninth mandate reads:

"the Board shall conduct research, including appropriate surveys; publish the results of such research; and recommend to the Congress and the President such action as may be appropriate to deal with any unresolved problems, issues, and questions associated with metric conversion, or usage, such problems, issues, and questions may include, but are not limited to, the impact on workers (such as costs of tools and training) and on different occupations and industries, possible increased costs to consumers, the impact on society and the economy, effects on small business, the impact on the international trade position of the United States, the appropriateness of and methods for using procurement by the Federal Government as a means to effect conversion to the metric system, the proper conversion or transition period in particular sectors of society, and consequences for national defense."

This is the primary mandate justifying and guiding the research effort of the Board. All research and research-related activity has been conducted in accordance with this mandate. On one occasion, research findings were of sufficient importance to single them out and present them to the Congress and the President, as required by the mandate. The case had to do with workers in converted industries who regularly buy their own tools. Many such workers cannot or do not take advantage of the tax deductions available to them for tool purchases. The full cost of adding metric tools to their necessary array of tools was borne by the workers. The Board judged the problem to be of the nature contemplated by the Act and thus called particular attention to the research findings. All other findings have been identified through the annual reports to the Congress and the President, and through the distribution of specific research reports and summaries to the Congress, the President, and key persons in the Executive Branch and the private sector.

The findings of the research program are presented in various ways throughout this summary paper. To respond to the discussion of the ninth mandate, the research areas suggested by the Congress are presented with the research and research-related activities that respond to the areas.

B-8a: Impact on Workers and Different Occupation

- Effects of metric conversion on measurement, specification and process sensitive occupations (Ref. 7).
- Analysis of the survey of selected occupations sensitive to measurement change (Ref. 8).
- Effects of metric change on workers' tools and training (Ref. 9).
- Effects of metrication on worker safety (Ref. 10).

B-8b: Impact on Different Industries

- Survey of small businesses: issues in metric planning and conversion (Ref. 1).
- Costs and benefits of conversion to small business (Refs. 2 and 3).
- Going metric: is it for you - planning models for small businesses (Ref. 29).
- Metric usage study: a look at six case histories (Ref. 4).
- Survey of selected large U.S. firms and industries (the Fortune 1000) (Ref. 5).
- Conversion of retail fuel pump computers to sale by the liter (Ref. 11).
- Study of metric conversion of distilled spirits containers: a policy and planning evaluation (Ref. 19).
- Conversion data project (Ref. 27).
- The impact of laws on metric conversion (Ref. 17).

B-8c: Possible Increased Costs to Consumers

- Conversion of retail fuel pump computers to sale by the liter (Ref. 11).

- Consumers and the USMB (Ref. 12).
- Survey of consumer attitudes and awareness of the metric conversion of distilled spirits containers (Ref. 13).
- Study of metric conversion of distilled spirits containers: a policy and planning evaluation (Ref. 19).
- Supermarket survey of metric labeling (Ref. 30).

B-8d: Impact on Society and the Economy

- Survey and assessment of econometric models and data bases (Ref. 28).
- All the other studies cited.

B-8e: Effects on Small Business

- Survey of small businesses (Ref. 1).
- Costs and benefits of conversion to small businesses (Refs. 2 and 3).
- Going metric: is it for you - planning models for small businesses (Ref. 29).
- Metric usage study: a look at six case histories (Ref. 4).
- Conversion of retail fuel pump computers to sale by the liter (Ref. 11).
- Conversion data project (Ref. 27).
- Impact of metrication on productivity of small businesses (Ref. 31).

B-8f: Impact on the International Trade Position of the United States

- Metric usage study: a look at six case histories (Ref. 4).
- Standards writing organizations surveys (Refs. 24 and 25).
- Survey of small businesses (Ref. 1).
- Costs and benefits of conversion to small businesses (Refs. 2 and 3).

- Survey of selected large U.S. firms and industries (the Fortune 1000) (Ref. 5).
- Study of metric conversion of distilled spirits containers (Ref. 19).
- Study of the U.S. machine tool industry (Ref. 26).

B-8g: Appropriateness of and Methods for Using Procurement by the Federal Government as a Means to Effect Conversion to the Metric System

- Standards writing organizations surveys (Refs. 24 and 25).
- Federal procurement metrication--appropriateness and methods (Ref. 32).

B-8h: Proper Conversion or Transition Periods

- Survey of small businesses (Ref. 1).
- Costs and benefits of conversion to small businesses (Refs. 2 and 3).
- Going metric: is it for you - planning models for small businesses (Ref. 29).
- Metric usage study: a look at six case histories (Ref. 4).
- Survey of selected large U.S. firms and industries (the Fortune 1000) (Ref. 5).
- Study of metric conversion of distilled spirits containers (Ref. 19).

B-8i: Consequences for National Defense

- With the exception of the Federal procurement analysis now underway, no specific Board research activity has focussed on national defense matters.

In addition to the work cited above, additional topics have been examined:

B-8j: Legal Constraints on Metrication

- Study of metric measurement and legislation (Refs. 14 and 15).
- Antitrust issues (Ref. 16).

- The impact of laws on metric conversion (Ref. 17).

B-8k: Status Measurement

- Research techniques for assessing the status of metric use (Ref. 20).
- Study of the U.S. machine tool industry (Ref. 26).

B-9: Mandate 10: Annual Report

The tenth mandate reads:

"the Board shall submit annually to the Congress and to the President a report on its activities. Each such report shall include a status report on the conversion process as well as projections for the conversion process. Such report may include recommendations covering any legislation or executive action needed to implement the programs of conversion accepted by the Board. The Board may also submit such other reports and recommendations as it deems necessary."

All research and research-related activity has contributed to the two annual reports published to date. No specific observations need be made to those contributions; findings discussed in the annual reports have been reviewed above.

B-10: Mandate 11: Federal Structural Mechanism for Laws and Regulations

The eleventh mandate reads:

"the Board shall submit to the Congress and to the President, not later than 1 year after the date of enactment of the Act making appropriations for carrying out this Act, a report on the need to provide an effective structural mechanism for converting customary units to metric units in statutes, regulations, and other laws at all levels of government, on a coordinated and timely basis, in response to voluntary conversion programs adopted and implemented by various sectors of society under the auspices and with the approval of the Board. If the Board determines that such a need exists, such report shall include recommendations as to appropriate and effective means for establishing and implementing such mechanism."

The specific actions in response to the last mandate were a comprehensive review and analysis of laws, regulations and ordinances affecting measurement (Ref. 14) and the development of the Board's position on the need for a structural

mechanism for changing statutes, regulations and other laws (Ref. 15). The principal observation relevant to the 11th mandate is that the Board concluded that there was no need for Congress to provide a new structural mechanism. The observation was based on findings that:

- Existing laws and regulations at all levels of government do not constitute a significant legal barrier to voluntary conversion efforts.
- Not all legal references to customary units require change.
- Most of the required legal changes can be accommodated through administrative rule-making rather than legislative action.
- Voluntary conversion activity underway at the time of the study was not of sufficient magnitude to strain the effectiveness of existing mechanisms. The Board could not state whether voluntary conversion activity was being unduly inhibited by perceived legal barriers and perceived limitation of available change mechanisms.

The survey of large U.S. firms (Ref. 5) provided data suggesting that perceptions of legal barriers may be inhibiting conversion. Further study of the matter, among large firms (Ref. 17), indicates that some perceptions on inhibiting laws and regulations still exist, but that there is strong recognition of the suitability of available change mechanisms. Additional work in the general area of laws and regulations is represented by the Board's anti-trust guidelines (Ref. 16); see Section B-5d(2), above, for detailed observations.

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APPENDIX C

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APPENDIX C

PERSPECTIVE NUMBER 3: NATIONAL INCOME AND PRODUCTS ACCOUNTS

C-1: Approach

The USMB research effort has touched many areas of the U.S. economy. Because the USMB mandate to study the status of metrification was from a very broad view, no attempt was made to collect a coherent body of purely economic data, as would be required for a more narrowly defined economic study. Consequently, the types of information gathered vary from opinions and preferences of executives, information from services such as Dun and Bradstreet, and Standard Industrial Classification (SIC) of firms sampled in several of the USMB studies. A list of research studies that are used for analysis is provided at the end of this appendix as references.

Looking at the Research Office accomplishments from the perspective of the national accounts requires some explanation, both as to what this means and why it should be done. An important objective of a research program is exhaustiveness. The national accounts, consisting of several non-overlapping breakdowns of the U.S. economy, provide an approach to assessing the extent of coverage of the research program. Even though the national accounts are defined ultimately by flows of dollars reported to governments, they provide a framework for most of the areas of interest to the USMB.

The system of national accounts is built around the Gross National Product (GNP) and the National Income. These accounts measure different aspects of a nation's economic activity. They differ by capital consumption allowances and indirect business taxes. The latter is not of direct interest to this research overview. Table C-1 is a schematic of the two account systems.

The following table, Table C-2, taken from the Statistical Abstract of the United States 1980, shows two ways the GNP is commonly broken out: by consuming sector and by producing sector (data are for 1979). The first vertical bar in Table C-1 is represented by the consumption sector in Table C-2.

Table C-3 shows a break out of the National Income corresponding to the third vertical bar on Table C-1.

These three tables incorporate the interests and constituencies of the USMB. For example, consumers are represented by the line, "personal consumption expenditure," on Table C-2. The labor force is represented in Table C-3 by

Gross National Product

C - 2

TABLE C-2

GROSS NATIONAL PRODUCT-SUMMARY (1979)
(1979 Billions of Dollars)

Gross National Product	<u>2,368.8</u>
<u>(By Consumption Sector)</u>	
Personal Consumption Expenditures -----	1,509.8
Gross Private Domestic Investment -----	387.2
Net Exports -----	-4.6
Government Purchases -----	<u>476.4</u>
	<u>2,368.8</u>
<u>(By Productive Sector)</u>	
Business -----	2,017.9
Households & Institutions -----	77.2
Government -----	248.4
Rest-of-World -----	<u>25.3</u>
	<u>2,368.8</u>

TABLE C-3

NATIONAL INCOME BY TYPE OF INCOME
(Billions of Dollars, 1979)

Compensation of Employees	<u>1,459.2</u>
Wages and Salaries -----	1,227.4
Supplements -----	231.8
Proprietor's Income	<u>130.8</u>
Farm -----	32.8
Non-Farm -----	98.0
Rental Income of Persons	26.9
Corporate Profits	178.2
Net Interest	<u>129.7</u>
National Income	1,924.8

"compensation of employees." Business interests are represented as to organization, (corporate, non-corporate, etc.) and sector (agriculture, mining, manufacturing, etc.) in Table C-2, in its disaggregated form.

C-2: Metric Board Constituencies

The constituencies as defined by the Metric Conversion Act represent several aspects of the National Accounting System: supply of factors (labor, capital and land) to the business sector, and payment for these factors (Table C-3); value added by the business sector (Table C-2) and demand for business output, by household component and type of product.

Table C-4 shows the distribution of the Metric Board constituencies throughout the various accounts representing the economy.

It can be seen from Table C-4 that each column relates to at least one of the constituencies, except the household and institution, rental income, net interest, and rest-of-world production sectors. The X's in the table only signify inclusion of the constituency in the economic aggregate, not comprehensive representation. Nevertheless, this table shows that the Board constituencies, which were selected with metric issues in mind, are surprisingly comprehensive with respect to the economic classifications.

C-3: USMB Research Studies

For the purposes of surveying the contents of the USMB research and classifying it by its relevance to the economic aggregates mentioned above, the classifications in the columns of Table C-4 will be used. Columns 1,2,3,4,5,7,8, and 10 have direct relevance to the research: columns 6,9,11,12 and 13 are not applicable. The reasons for non-applicability are as follows. Proprietors (6) were not identified as such during the surveys. Undoubtedly, some of the firms questioned were proprietorships, but this information was not gathered by this categorization. Net interest (9) is interest paid into the household sector, beyond what is paid to other business establishments. Information on business from the organization standpoint (i.e., corporations vs. proprietorships and others) was not collected by this categorization. Household, government, and rest-of-world, (11, 12, and 13) as producers, have not been addressed. The remaining eight groupings form the basis of the discussion.

TABLE C-4
DISTRIBUTION OF USNS CONSTITUENCIES
THROUGH THE ECONOMY BY TYPE OF ACCOUNT

	GNP - Consumption Sector				National Income By Type of Income						GNP - Productive Sector			
	Personal Consumption 1	Gross Private Domestic Investments 2	Net Export 3	Government Purchases 4	Compensation of Employees 5	Proprietor's Income 6	Rental Income 7	Corporate Profits 8	Net Interests 9	Business 10	Household Institutions 11	Government 12	Rest of World 13	
Board Constituency														
Engineering					X									
Science					X									
MAN		X	X			X		X		X				
DOC		X	X			X		X		X				
AFI/CIO					X									
Government/ States				X								X		
Small Business		X	X			X		X		X				
Construction		X				X		X		X				
Weights & Measures				X								X		
Education					X	X		X		X				
At Large/ Consumer	X		X											

Table C-5 displays the research studies and the interaction with Demand (by Sector), Income (by Type) and Supply (by Standard Industrial Classification).

C-3a: Gross National Product Accounts

C-3a1: Consumption Expenditures

Table C-5 shows that several USMB research studies are concerned to some extent with consumers. Most of these citations are indirect, through business' eyes, such as in the "Six Case Studies" report (Ref. 1). The most important consumer study in a direct sense is the consumer survey found in the Distilled Spirits Study (Ref. 2). There the somewhat contradictory nature of consumer studies was displayed. For example, 58 percent of distilled spirits purchasers report little or no difficulty in making price comparisons while another 26 percent do not make price comparisons. Yet 78 percent of such purchasers had no awareness of the quantity of product in the bottles they bought. Few complaints were registered. This shows clearly that metric conversion does not necessarily kill consumer demand.

Another interesting consumer survey commissioned by the USMB is due in late summer 1982 (Ref. 3). Consumers will be surveyed indirectly by examining the state of metric labeling on the packages they buy in supermarkets. Sales figures will be available for these product classes, so it may be possible to examine the extent to which metric labeling helps or hinders sales. This study is being performed in cooperation with the U.S. Department of Agriculture.

C-3a2: Net Domestic Investment

Investment means construction, durable goods and inventory. As such, the latter two categories have been more involved in metrication than the former, although such things as building codes are very much of interest in USMB legal studies (Refs. 4,5,6 and 7). Firms are very much concerned with building codes as potentially affecting attempts to invest in metric construction. Firms see no real barrier to conversion, however.

In the area of producers' durables, considerable work has been done in the small business sector (Refs. 8,9,10,11 and 12) where it was found that a variety of situations exist: totally metric operations; firms with potential metric markets but little interest in developing them or exporting; and firms with low levels of metric investment, primarily manufacturing in conventional units. Among small manufacturers, none was found with as much as \$50,000 invested in purely metric capability. Generally the investments ranged from \$1,000 to \$5,000.

TABLE C-5 METRIC RESEARCH STUDIES AND THEIR RELATIONSHIPS TO THE NATIONAL ACCOUNTS
BY DEMAND BY SECTOR, INCOME BY TYPE AND SUPPLY BY SIC

Ref. No.	STUDIES (short title)	DEMAND (by Sector)			Income (by Type)			Supply (by SIC)
		Consumption	Investments	Net Exports	Government	Employed Income	Corporate Profits	
1	Six Case Histories	X	X	X	X	X	X	X
2	Distilled Spirits	X						
3	Supermarket Survey	X						
4	Metrie & Legislation				X		X	X
5	Metrie Option				X			
6	Antitrust				X			
7	Legal Impediments				X			
8	Small Business Issues		X	X			X	X
9	Small Business Investments		X	X			X	X
10	Small Business Consequences		X	X			X	X
11	Small Business Models		X	X			X	X
12	Small Business Productivity		X	X			X	X
13	Distilled Spirits Conversion	X	X	X	X	X	X	X
14	Distilled Spirits Policy Eval.		X	X	X		X	X
15	Fortune 1000 Survey		X	X			X	X
16	Machine Tools		X	X			X	X
17	Federal Procurement				X			
18	Metrolgy Sensitive Occupations							
19	Survey of Workers					X		
20	Worker Tool and Training					X		
21	Worker Safety					X		
22	Conversion Data	X	X	X	X	X	X	X
23	Research Techniques							
24	Gas Pump	X	X					
25	Consumers and USMB	X	X				X	X
26	Econometric Models	X	X				X	X
27	Metrie America	X	X	X	X	X	X	X
28	Getting an Understanding	X	X	X	X	X	X	X
29	Shipping Containers	X	X	X	X	X	X	X
30	International Standards							
31	Engineering Standards			X				X

Inventory is sometimes overlooked as a demand of investment. Inventory management is very important especially for small business (Refs. 8, 9, 10, 11 and 12) when interest rates are high. Inventory practices are always subject to scrutiny when metrication is being studied or planned. Reduction of inventory costs was a major consideration in the distilled spirits conversion, (Refs. 13 and 14) where a main result was fewer sizes and styles to stock. It is also possible that duplication due to dual stocking can raise the prices of both metric and customary items, particularly in highly variable or slow moving stock.

C-3a3: Net Exports

Net exports is just exports minus imports, i.e., a "leakage" of output. USMB research has addressed the perceived effects of metric change on firms' abilities to export, but the obverse side of the coin, imports, has not been addressed. The Fortune 1000 study, (Ref. 15) as well as the small business studies (Refs. 8,9,10,11, and 12) have taken pains to understand the factors that determine a firm's ability to export to foreign markets. USMB research has taken two indirect routes: asking executives of the firms what effect they think metrication would have on their exports, and compiling the numbers and characteristics of firms that do export. The survey of small business (Ref. 8) found that 12 percent of the firms had some level of exports - manufacturers led with 26 percent engaged in exporting. Metrication clearly has a positive connection with exports since 23 percent of all small business deal in metric products, 40 percent of exporting firms deal in metric products.

The findings for Fortune 1000 (Ref. 15) firms are that of all responding firms, 57 percent have foreign metric sales, while of responding firms who consider themselves to have metricated, 91 percent have some combination (soft, hybrid or hard converted) of metric exports. A possible conclusion is that for large firms, exports and metric activity are much more closely tied than for small business.

As seen in the Machine Tool Status Assessment (Ref. 16), this industry has a declining share in the international market which is four times the size of the domestic. It also points out the increase of imports into the U.S. especially from Japan.

C-3a4: Government Purchases

The government (Federal, State and local) as a demander of goods and services has been treated indepth by only one

study, the Federal Procurement study (Ref. 17). This study is nearing completion, and will be a comprehensive statement on the role of metrication in non-defense government procurement. Other studies (Refs. 4-6) have discussed the Federal, State and local government and regulatory roles.

C-3b: National Income Accounts

C-3b1: Employees

The work done by the USMB Research Office in the direct effects metrication has on the income of individuals was a series of studies in the area of metrology-sensitive occupations (Refs. 18, 19, 20 and 21). It was found that transportation mechanics and tool and die makers combined large requirements for metric tools and large personal expenditures. Most tools in most other occupational areas are provided by the employer, whether private or government. Training is provided by employers almost entirely, both metric and non-metric, with small exceptions in clerical and programming areas. These exceptions may not be statistically significant.

C-3b2: Rental Income

The only connection with renter's income and metric change that has been dealt with in USMB research is in the area of building codes. This is mentioned above under Net Domestic Investment (C-3-a). Land and construction are two areas with only minimal metric activity. If metrication starts, there may be an immense impact on standards, laws and regulations of building codes and on the builders.

C-3b3: Corporate Profits

Profits for a firm is revenues minus costs. To increase revenues a firm must sell more; to decrease costs firms must become more efficient with respect to its production and finance structures. Metric issues are involved in the former, briefly: (i) areas of consumer and industrial resistance to metric products and (ii) attempts to expand exports. Both these subjects were discussed in the consumption and net exports accounts mentioned above. Metric issues involved in decreasing costs are: (i) potential tax breaks for metric investment, (ii) more efficient capital equipment incorporating metric units and (iii) measures to control inventory costs. These, too, were mentioned in the investments account above, but very little of a substantive nature is known of actual economic impacts of metric change in these areas.

C-3c: Supply Side (Business Only, By Industrial Sector)

This classification holds the biggest potential for economic analysis, narrowly defined. The Fortune 1000 study (Ref. 15), The Survey of Small Businesses (Ref. 8), The Impact of Laws on Metric Conversion (Ref. 7), The Conversion Data Study (Ref. 22), The Machine Tool Status Assessment (Ref. 16), and The Search for Small Businesses with Investment in Metric Production (Ref. 9) have all surveyed or addressed the business community according to the Standard Industrial Classification (SIC) of their output. Over 100 SIC (and SIC related) classifications have been investigated.

C-4: Summary

A chart (Table C-5) has been completed relating the research studies to the aggregates chosen for this appendix. Most of these are of interest but not in a systematic, comprehensive way. Those that are have been mentioned in the text. Most of the information has been of a qualitative nature and not quantitative, which is necessary to truly assess the impact of metrification on the U.S. economy and society.

There are many opportunities for further study - primarily in the industry or SIC areas. A comprehensive study of these industrial classifications would be the necessary cornerstone of any attempt to draw nationally valid conclusions about the effects metric change has on the U.S. economy. It would also form the basis to study the effects of the economy on the progress of metrification.

APPENDIX C - REFERENCES

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